INSTITUTO TECNOLÓGICO Y DE ESTUDIOS SUPERIORES DE
MONTERREY

CAMPUS MONTERREY

ESCUELA DE INGENIERIA Y TECNOLOGIAS DE INFORMACION
PROGRAMA DE GRADUADOS EN INGENIERÍA

A RESTRICTED MULTIPLIER DEA MODEL FOR IDENTIFYING BEST
PRACTICES FOR ATTRACTING STUDENTS INTO A MEXICAN UNIVERSITY
CASE STUDY: ENCSH AT ITESM

TESIS

PRESENTADA COMO REQUISITO PARCIAL PARA OBTENER EL GRADO
ACADEMICO DE:

MAESTRO EN CIENCIAS CON ESPECIALIDAD EN SISTEMAS
DE CALIDAD Y PRODUCTIVIDAD

POR:

SONIA VALERIA AVILÉS SACOTO

MONTERREY, N. L.   MAYO, 2012

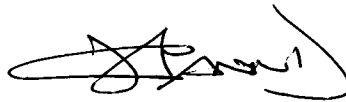# INSTITUTO TECNOLÓGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY

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ESCUELA DE INGENIERIA Y TECNOLOGIAS DE INFORMACION PROGRAMA DE GRADUADOS EN INGENIERÍA
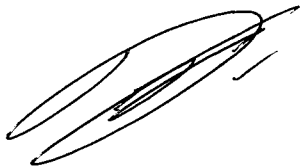
Los miembros del comité de tesis recomendamos que el presente proyecto de tesis presentado por Sonia Valeria Avilés Sacoto sea aceptado como requisito parcial para obtener el grado académico de:

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Mayo, 2012

A RESTRICTED MULTIPLIER DEA MODEL FOR IDENTIFYING BEST
PRACTICES FOR ATTRACTING STUDENTS INTO A MEXICAN UNIVERSITY
CASE STUDY: ENCSH AT ITESM

POR:

SONIA VALERIA AVILÉS SACOTO

TESIS

PRESENTADA AL PROGRAMA DE GRADUADOS EN INGENIERÍA

ESTE TRABAJO ES REQUISITO PARCIAL PARA OBTENER EL GRADO
ACADEMICO DE MAESTRO EN CIENCIAS CON ESPECIALIDAD EN
SISTEMASDE CALIDAD Y PRODUCTIVIDAD

INSTITUTO TECNOLÓGICO Y DE ESTUDIOS SUPERIORES
DE MONTERREY

Mayo, 2012

DEDICATION

To GOD, for his love, guidance and blessing.

To Virgin Mary, for her protection and for being the guide on my way.

To my parents Jaime and Sonia, for their unconditional love and support, for being my guide and for their advice in every moment of my life.

My sister Estefanía Caridad, my best friend, for her advice and teachings which have generated strengths in my life.

To my family, for supporting me to go ahead, for giving me encouragement and the inspiration to go far.

ACKNOWLEDGMENTS

SUMMARY

The long-term survival in an organization depends on and requires practices and features which create competitive advantage and differentiators from their peers, allowing more clients to become attracted to them. This implies that an organization has market-oriented practices which help not only to understand what their customers want from them, but also what attracts them. This thesis is focused on identifying a methodology which could contribute to establishing best practices that can have an impact on the organization, giving them a competitive advantage. This requires recognizing those dominant players and their practices, which could be adopted in order to become a 'choice' to prospective customers. It is here that DEA plays an important role, because it lets the organization be compared to its competitors, and can thus determine those peer institutions whose practices, if they are adopted, would help it to fulfill its purpose to be a better option in the market place.

This research is presented in the form of a case study, aimed at identifying ways to improve the performance of a particular institution, the Business school from ITESM – ENCSH from the Spanish "Escuela de Negocios, Ciencias Sociales y Humanidades" (ENCSH), in terms of its ability to attract students.

The structure of the study is as follows:

Chapter 1 describes briefly general information about the case study, and the relevant characteristics about the structure of thesis.

Chapter 2 includes the methodology to be carried out in this thesis and all the steps to analyze the data, ultimately aimed at identifying best practices.

Chapter 3 reviews the literature necessary to complement the research. It is divided in three areas: benchmarking, best practices and efficiency modeling (DEA).

Chapter 4 includes the application of the methodology using DEA models for evaluating the relative efficiency to the Business School – ENCSH from ITESM; in addition, this chapter includes a new DEA model to evaluate the relative efficiencies of the different business schools.

Chapter 5 shows the results obtained in the study and the conclusions obtained by this research and the methodology applied.

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CHAPTER 1: INTRODUCTION

1.1 Background

Currently worldwide, there has been a rapid growth in the offerings of the universities and colleges. When applying to a university, students tend to focus on the results that they could gain after their studies. Therefore, there is an opportunity for institutions within the Higher Education market to adopt or increase their interests in certain features, characteristics, and competitive differentiators, which are attractive for students when they are selecting a university.

In this situation, the Instituto Tecnológico y de Estudios Superiores Monterrey (ITESM), an institution that has been characterized by being within the world ranking of the best universities, cannot afford to lose student demand, and one way is to meet the needs and requirements of those students. It is here where the question arises: What are the best practices for attracting students into universities? Studies of this type, which are included within the economics of education, are needed in order for institutions like ITESM to take appropriate action. This will enable ITESM to gain ground relative to those institutions that possess and know how to make effective use of the information provided by their customers, namely their "Students".

1.2 Problem definition

This thesis addresses the following question:

What are the best practices for attracting students into universities?

Worldwide, Higher Education Institutions (HEI's) require information about all features, factors or practices that all of their futures clients, their students, will consider. For that reason it is very important that every institution have market-oriented practices which help not only to understand what students want from them, but also what attracts them to an institution. To examine the above question in the context of higher education, we need to look at three issues:

Issue 1: Which university appears to dominate in attracting students in the market in which ITESM competes?
Issue 2: What are the best practices of those dominant players?
Issue 3: Within those best practices, which are the most important to students?

The following figure will describe the problem definition of this research thesis
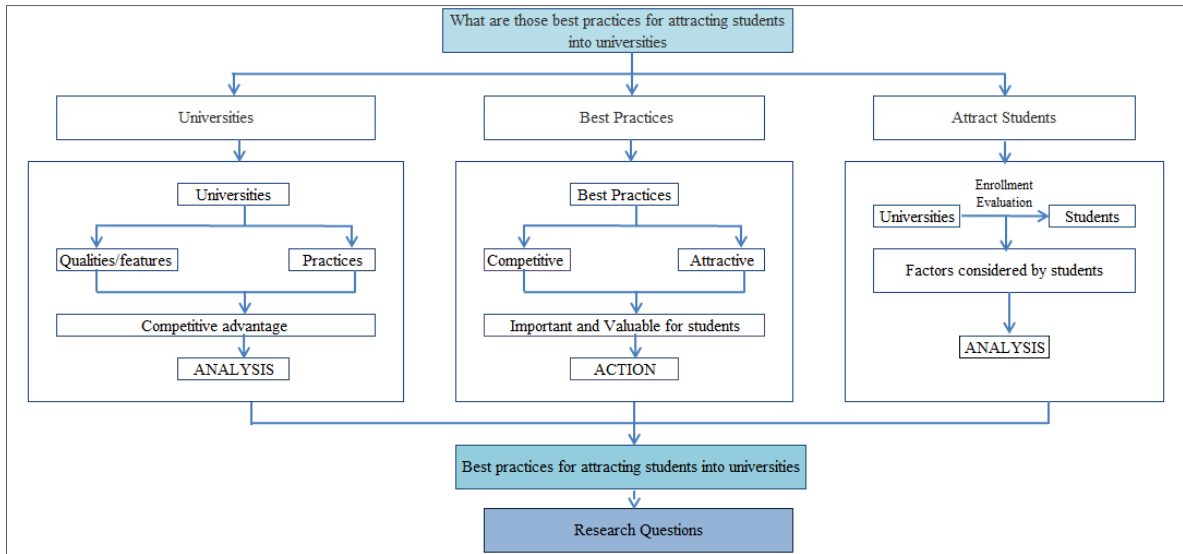
Figure 1: Chart of the problem definition

1.3 Objectives

1.3.1 General objective:

The general objective is to apply a benchmarking tool aimed at identifying those institutions that appear to be following best practices for attracting students into Mexican universities. This is done by way of a case study focused on ITESM.

1.3.2 Specific objectives:

1. Provide an in-depth research and analysis involving the factors and elements considered by students at the time of choosing a university.
2. Apply an extended version of a benchmarking tool called Data Envelopment Analysis (DEA) to a large set of universities including ITESM. This will aid in identifying those institutions that are the leaders in education, in the sense that they are providing the most attractive features for their students. At the same time, the benchmarking tool will provide a measure as to where ITESM stands relative to those best performers.
3. Propose a list of best practices and plans that can be adopted by the ITESM.

1.4 Research questions

1. What are the main characteristics or factors considered important by students when selecting a university or college?
2. How can one identify those universities that are most attractive to students?

2.1 Where does ITESM stand relative to those factors considered by students to be important?

2.2 Where should be the university under study be positioned in order to be considered efficient?

3. What are the main differences between the university under study and those for which the benchmarks were developed?

4. What are the best practices applied by the "best universities" to attract students?

1.5 Justification

The universities have realized that their long-term survival depends on how well they serve their customers. At the same time, it is necessary for institutions to adopt a variety of methods, practices, features or characteristics, which will allow them to be at the same level as their peers. One of the problems faced by educational institutions is that in most cases, their assessment data regarding the service and what their customers expect, are out of date or refer to what "has been" done. The data often do not focus on what is happening now or that may happen in the future. Hence, to survive in a competitive market and increase the attraction of students to the HEI under study, ITESM, it is necessary to determine those practices whose implementation will attract students. For this, it is necessary to determine the practices of ITESM's peers, and then try to adopt them in order to become a university of 'choice' to prospective students.

It is here that DEA plays an important role. DEA allows the organization to be compared to its competitors, and can thus determine those peer universities whose practices, if adopted by ITESM, would help it to fulfill its purpose to be a better option in the market place.

1.6 Structure of the thesis

The method to reach the objective of this research has been divided in four main areas, which are literature research, data collection, the application of tools and results of the previous steps.

1. The literature research is a critical first step because it provides all the important information regarding the different issues reviewed in this research. Further, the information will be the base line for the steps that follow.

2. The data collected involves relevant information, which could be statistical or literary, required to reach the desired objective.

3. Two main tools are applied herein, namely (1) a survey of customers of the organizations under study, and (2) a software package "DEAFrontier.xlam" to get the results needed to get the desired results.

4. The results constitute the information relating to the objective of the research.

In Figure 2 it is shows the scheme of this research work.
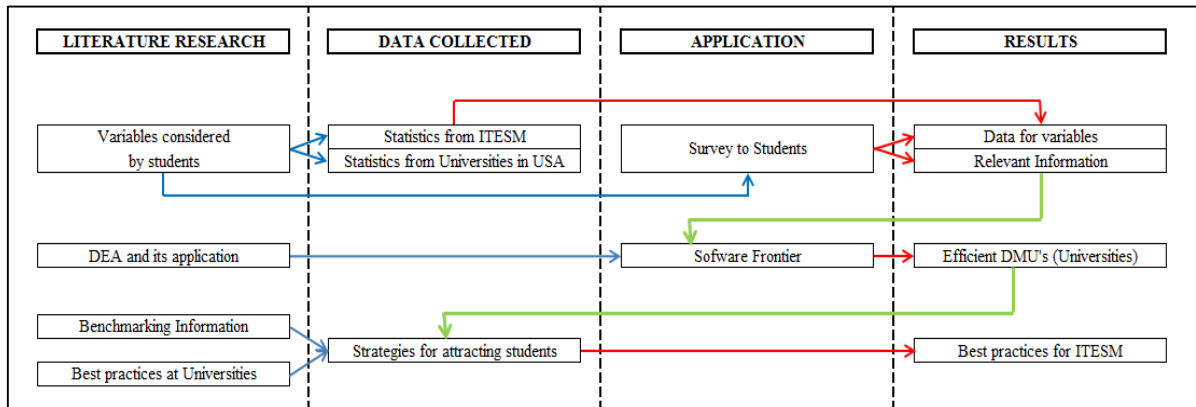
Figure 2: Structure of the thesis project

Those steps (boxes) linked by red lines give directly information to get the desired results. Those which blue lines, show the previous information already reviewed to continue with the research. Finally, those with green lines link the earlier results which are used in the future steps to reach the objective.

1.7   Scope and limitations

The scope of the investigation can be classified partially as descriptive and exploratory. Specifically, the research is presented in the form of a case study, aimed at identifying ways to improve the performance of a particular institution in terms of its ability to attract students. The study is supported by a major data collection initiative involving a large set of universities. In particular, data from the Business school – ENCSH from the Spanish "Escuela de Negocios, Ciencias Sociales y Humanidades" (ENCSH) from ITESM, will be used.

The study aims to set specific benchmarks for that institution, as well as to put forward a list of recommended best practices. At present, there are no studies or cases such as this that apply efficiency measurement tools to higher education institutions, with the principal aim being the identification of best practices or opportunities for attracting students.

The thesis, in addition to being exploratory and descriptive, also presents new methodology in the form of a modified DEA model. The need for this modification arises from the observation that the structure of the problem is one where the conventional input to output relationships, inherent or at least assumed, in the standard DEA approach, are not entirely applicable herein. This modification is detailed later.

4

To implement the resultant DEA model, we apply a particular software package "DEAFrontier.xlam" for Excel 2007 or 2010 with the excel standard solver, which includes a restricted multiplier model. In this way, it is possible to identify those universities that would be classified as efficient, provide a measure of efficiency for the university under study, and set targets for improvement.

CHAPTER 2: METHODOLOGY

2.1 Introduction

This chapter describes the methodology to be carried out in the thesis. The following flow chart describes the steps constituting the methodology.
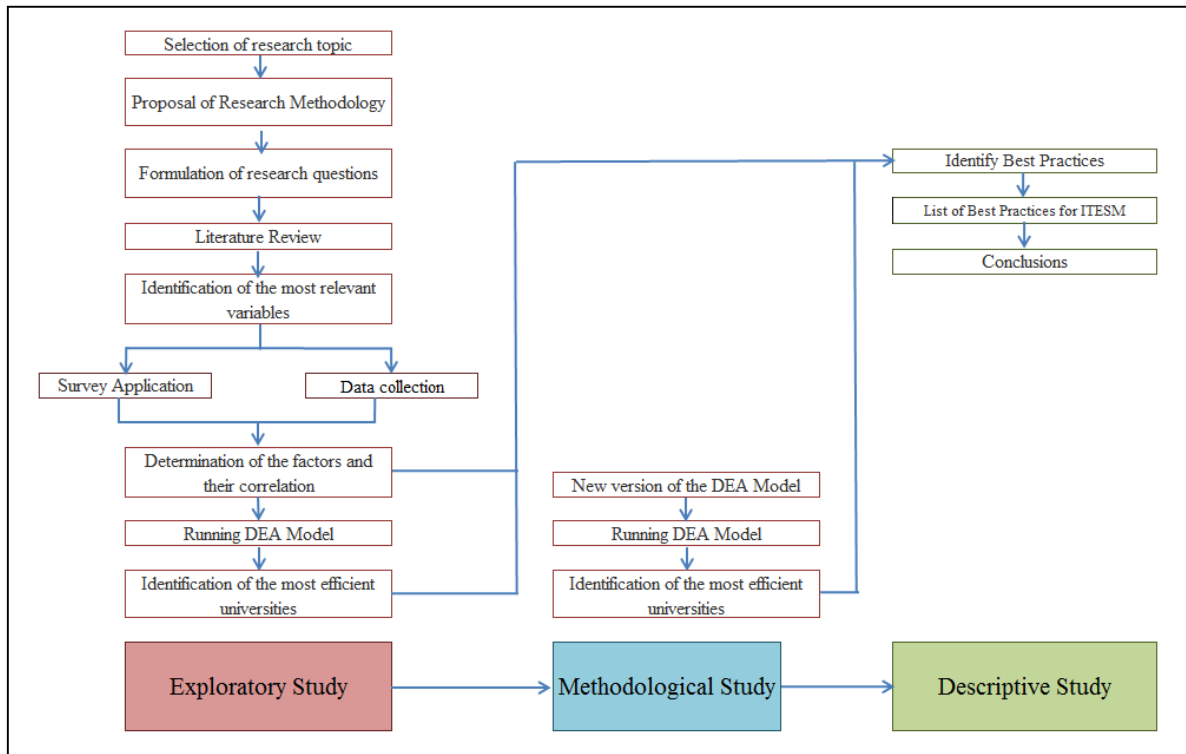
Figure 3: Workflow for the thesis research

2.2 Statement of the problem and objectives

The problem and objectives are clearly stated in Chapter 1

2.3 Type of study

The study here can be considered as involving three things: exploratory, descriptive and methodological.

1. Exploratory: DEA has been applied in many sectors and countries. An interesting sector is higher education. Although DEA has been part of many

studies on higher education, there no study which focuses on determinating those institutions that have the best practices for attracting students. Therefore it is considered that this research with the application of this tool has high impact and results. For this reason the present research is exploratory in that the process and the tool have greater utility in identifying those opportunities to attract students.

2. Descriptive: this research is partly descriptive because it will describe all the properties and important features needed by a university to have the best chance attracting greater number of students.

3. Methodological: this study involves new methodology development in that a modified version of the DEA model will be presented.

2.4 Literature review

Chapter 3 will review the literature in three areas, namely:

1. Benchmarking
2. Best practicing
3. Efficiency modeling (DEA)

This review is designed to acquaint the reader with these broad areas. In addition the review sheds light on how these areas, when taken together, allow not only for an evaluation of efficiency of each decision making unit (university), but also will identify benchmarks and subsequent delineation of best practices. This latter is particularly important in that the case study (Chapter 4) is intended to aid ITESM in improving its stature regarding its attractiveness to existing and prospective future students.

2.5 Data collection: Identifying relevant predictors of success as a HEI

Part of the literature review in the area of benchmarking uncovers those factors that other studies have identified as characterizing top performing HEIs. With that backdrop, the case study in Chapter 4 discusses the data collection initiative that was undertaken, with the specific purpose being to develop the appropriate information needed to evaluate relative efficiency of the HEIs considered.

2.6 Modeling efficiency and identifying benchmarks

A major part of Chapter 4 will be the application of the Data Envelopment Analysis (DEA) methodology described in Chapter 3. The following process chart identifies the steps to be followed.
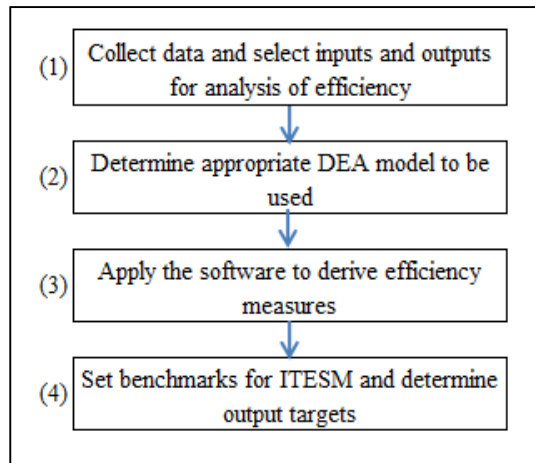
Figure 4: Process of modeling efficiency

2.6.1 Selecting inputs and outputs (1)

Using the data collected and relying on earlier literature for guidance, appropriate input and output factors will be selected.

2.6.2 Model selection (2)

Perhaps the most critical stage in any efficiency evaluation exercise is selecting the appropriate model. This is generally driven by the goals of the organization as well as by the inputs and outputs chosen. In the current setting, it will in fact be necessary to adapt the conventional DEA structure in order to properly capture the process.

2.6.3 Software application (3)

As indicated earlier, the software to be used is DEAFrontier.xlam. This software caters to a wide variety of model structures.

2.6.4 Benchmarking and target setting (4)

The outcome from running the software is an efficiency score for each of the institutions in the sample. This score indicates the gap between the performance of an institution and that of the best performers in the sample. The software also specifies which of those best performers, any given "inefficient" DMU should try to emulate. Finally, performance measures and targets for each inefficient DMU are provided.

2.7 Determining best practices

In this step, after the benchmarking process has been completed for the institution under study (ITESM), a list of all the features will be examined to identify what can be adopted or what should be changed, in order to increase customer satisfaction.

The greatest effort in the present investigation is to determine those practices to be used as a result of all the analysis among institutions, and which will aid in attracting clients to the organization. Finally, a list of all the best practices will be presented, with data or examples that will help to understand the importance of the adoption of these practices.

CHAPTER 3: LITERATURE REVIEW

3.1 Part I: An in-depth review of the variables considered by undergraduate students when choosing a college or university

Higher education is viewed as a competitive attribute, which not only ensures the needed skills of human capital, but also the vehicle for acquiring advanced knowledge; essential elements for an economic growth in an organization [1]. However, students from high school are able to choose from among a great variety of offerings and competition has intensified. As a consequence, there has been a decrease in the student enrollments in some universities, which have historically experienced large numbers of consumers. In order to combat this situation, Colleges and Universities need to create an environment that contributes to increased enrollments. This requires focusing on what students consider important in their decision to apply to a specific institution.

At this time, several questions arise: How do students choose a university? How do students search for information about them? How are students influenced by this information? How do students judge that information that they obtain in their search process? [2]. Morse & Flanigan [3], suggest that these questions lead to a comparisons of concrete factors that are considered by students. "Students should seek a school that fits their personal goals, values, and personalities" [4].

Although all universities make their best efforts, and each one has certain distinguishing features that could be attractive to students, most students apply to more than one university. Institutions fall into three groups (Brennan [2]): "a group of institutions that the student would like to attend, but which may not accept them, a group of institutions that the student would be able to attend but which the student would rather not apply to, and a group of institutions that the student would not apply to under any circumstances".

It is well know that in today's environment, students seek data to make decisions about universities [5]; they look at many issues, and this situation has become much more complex than in the past with the continued growth in the number of higher education institutions available. Evidence of this assertion appears in the web page of *Ranking Web of World Universities*, offered by *Web of Metrics,* that shows the following table (Table 1), containing the number of universities around the world.

Although universities and colleges are complex organizations with many features and qualities, they are subject to consumer choice or selection, where judgments are made on the basis of a broad range of 'added value' expectations [5]. The criteria for making selections among universities vary from one consumer or stakeholder to another, in this case the student. In this point, it is necessary to

consider their psychology as a consumer, in order to ensure recruitment, retention and new enrollments.

Table 1: Number of universities operating around the world [6]

CONTINENT	NUMBER OF COUNTRIES	NUMBER OF UNIVERSITIES
Africa	47	635
America	41	7,006
Asia	45	4,964
Europe	54	4,976
Oceania	12	135

The identification of features for the improvement of student recruitment requires answers to certain questions: "What are the customers' needs?, How should those needs be addressed, and how can performance be improved" [6]. In this way, "organizations will have an effective development, and their future success will increasingly be determined by how they identify and satisfy their various customers"[7].

First of all, it is important to understand what encourages students to select a Higher Education Institution. An approach is to recognize those factors included in the behavior and the consumer decision-making process, which comes after moving through a number of stages and environments experienced by students. However, it is very important to emphasize the last stage, which is when students become part of the education product offered to the world, and this situation includes a significant contribution to them. Maguad [7] mentions that many people believe that "if you put good things together, something good will come out of it". This phrase in the education context means that if universities want to improve their portfolios and reputation, and create strategies that meet the requirements of the consumer sector, using or acquiring their resources or eliminating those that aren't relevant to students and are obstacles to attract students, it is necessary to get knowledge of what students consider important for choosing a university.

Maguad [7] states that in these times, students are increasingly looking for more options and features from education offerings. Although, there is a huge number of alternatives around the world, students tend to concentrate on one institution that is able to meet their expectations, providing all the advantages that come from being enrolled there, and all of the opportunities for acquiring skills, gaining knowledge, and learning about the world. Statistics illustrated by Clinedinst & Hawkings [8] show that "students are submitting a greater number of applications, as a response to real and perceived increases in competition". Furthermore there has been an increase in the number applying online.

Institutional services and HEIs are different from the other services. This is because the labor market benefits from the knowledge and skills acquired by students and contributions they will make. For that reason, students are looking for a university which gives them confidence and drives them to pursue their dreams and desires in professional life [7]. Thus, students can be particularly attracted to a university that will produce a long-term positive effect in their lives. Briggs [5] and Stern [9] concluded that the majority of students make their college enrollment decision based on:

1. Educational and career aspirations where there is a match to what the college have to offer.
2. Financial attributes, especially because of the recession economy suffered in the last years.
3. Reputation in terms of student and professional life.
4. College information about life and school experience, which includes a personalized or customized communication to students, can achieve an edge against competitors.

Stern [9] has proposed an approximation of the weights assigned to those characteristics considered by students, as shown in Table 2:

Table 2: Weight considered by students when choosing a college

CHARACTERISTICS	PERCENTAGE
Academic Programs	55 %
Reputation	15 %
Cost	14%
Financial Aid	9 %

Students' expectations show a continued increase. At this point, it is necessary that universities create strategies that will meet demand, and will create an attractive image to students, supported by quality and efficiency in their activities. Furthermore, Briggs [5] points out that there are different groups of stakeholders, who have the same level of importance as students, and who also consider many attributes from HEIs, and have a significant influence on the institutional decision. These stakeholders include parents, friends, guidance teachers, recruitment visits and schools advisors. For that reason, it is extremely important to find those relevant factors considered by all stakeholders.

Student surveys have shown that one of the main factors influencing students' college choice is the academic service. This includes intellectual emphasis, the approach to learning tasks, and the course options at the university related to the subject offerings or majors offered and the type of delivery (part time or full time study). In addition, it includes courses offered by distance education (external studies), or the emerging 'virtual' university courses available on the Internet [2].

This caracteristic always depends on the level and type of aspiration and the student performance, and it has been demonstrated that when students believe that their studies will lead directly to accomplishing their goals, they are motivated to join that institution.

Additionally, not all colleges and universities offer all possible combinations of majors, and therefore students with a strong sense of vocation will seek only those institutions that offer majors in their chosen career paths [2]. Students are looking for those colleges that offer activities as Di'Maria [4] suggests, such as "studying abroad, internships, or opportunities to enroll in courses outside the major, whether the departments have enough faculty members to provide different viewpoints and specialties within the major, and whether faculty members are accessible for academic advising, mentoring, and extra help".

Another factor of immense significance to students is the 'Academic Reputation', because of the educational product offered; statistics show that certain HEIs earned a reputation 50 to 100 years ago and remain famous. In fact, students want to be in a college where family or friends have already perceived socio-economic awards. There is also the sense of being part of a prestigious institution, where they will be able to develop skills and characteristics which contribute "added value" not only to closer family members, but also to the labor market. This situation causes many stakeholders to turn their minds to a given institution, resulting in loyalty toward that institution.

In the research done by Brennan [2], she identifies three types of institution's reputation: "*General* reputation which is not associated with any particular characteristics of an institution, *academic* reputation which is about academic programs and standards of the institution and, *alumni* reputation", which is the "product" offered to the labor market". However, these three elements converge into a single point that emphasizes the nature and extent of institutional products, characteristics of graduating students, success of alumni, research and scholarly publications, and public service. They are built on the assumption that "HEIs are accountable to society for what they produce and being judged on the basis of their demonstrated outcomes" [7]. "Then again, students should examine the college's faculty, how it has fared in surveys, check the Web site, and elicit feedback from alumni to determine if that reputation is earned or outdated" [9].

Students seek institutions according to their perceived ability to meet the requirements of the study programs, which will maximize the potential returns, socially or economically. Academic reputation or prestige is associated with the consumer behavior which faces two types of choices, the same as when people who buy prestige products buy them because they are not generally available to all. This happens in the same way with HEIs, in that the less selective the institution is, the more applications will follow, as students will apply to an

institution that they believe will have them. In short, students consider the Admission rate from the institution which will allow the student to be enrolled or not. However, the higher level students will not take up places at the more accessible institutions, as they will gain places at more selective and therefore more desirable institutions. Thus, selection processes become part of the criteria for choosing an institution. On the other hand, "the student will choose to apply to an institution where they know in advance the probability of acceptance, and will not willingly choose to apply to an institution where they face being rejected by the admissions process" [2].

The next table helps to make a competitive analysis between countries in terms of the entry rate to higher or tertiary education:

Table 3: Number of universities and tertiary education entry rate in countries members of OECD [6, 11]

Country	Number of universities	Percentage of entry rate	Country	Number of universities	Percentage of entry rate
Australia	91	86	Korea	398	61
Austria	77	42	Luxembourg	4	M
Belgium	100	30	Mexico	906	32
Canada	204	M	Netherlands	160	60
Czech Republic	57	54	New Zealand	45	76
Denmark	95	57	Norway	67	66
Finland	51	71	Poland	433	78
France	581	M	Portugal	111	64
Germany	411	34	Slovak Republic	33	74
Greece	64	43	Spain	236	41
Hungary	75	63	Sweden	50	73
Iceland	9	73	Switzerland	107	39
Ireland	50	44	Turkey	162	29
Italy	203	53	United Kingdom	233	55
Japan	716	46	United States	3274	65

M: Data is not available

Another important consideration for students regarding the choosing of universities, is the "high requirements" advertised by the institution. It is well known that more prestigious "selective" universities ask for high A-level grades and high personal qualifications. Some studies have found that all institutions maintain a strong desire to recruit what they perceive to be the "most able" students[10].Thus, the promotion of excellence of the education service given by them will enhance their reputation in the market place. For that reason institutions may also compete for students, especially talented ones, who will represent potential future researchers, executives, politicians or ambassadors of their *alma mater* as well, playing a crucial role in shaping of an HEI's reputation[11].

The cost of education, in the form of tuition fees, constitutes a barrier when selecting a college or university. Such fees often represent the first consideration on the part of the student. Research has shown that many students give this top priority when applying to university. In the survey applied by Clinedinst & Hawkings[8], the result was that "many students and families were reevaluating college application plans and enrollment decisions with more weight placed on financial concerns". Students now expect greater value for money. Many believe that by paying for an excellent education, they will earn economic rewards at the completion of their studies. This assertion is supported by many studies such as that by Jones [12]. He asserts that students expect that the cost of a superior education will be recovered by gaining enough knowledge to face the labor world and provide them the capability to earn good or excellent salaries. Mancheno [1] claims that in today's environment "individuals acquire education in order to produce increasing economic returns".

On the other hand, many students strive to find those institutions which will provide financial aid to cover part or all their tuition. In this way, those students who have a higher Intelligence Quotient (IQ) receive scholarships and thereby acquire knowledge at lower costs. However, many will have to study in the most challenging and long career paths[1]. In his research, Stern [9] explains that because of the recessionary economy, students tend to think more about financial aid, or alternatively opt for public colleges and community colleges because of their lower tuition.

In the Report of enrolment in private and public institutions it is easy to visualize the number of students, during 2008 and 2009, enrolled in HEIs. The next table shows a comparison of most of the countries analyzed by the Organization for Economic Cooperation and Development (OECD), a unique forum where governments work together to address the economic, social and environmental challenges of globalization.

Table 4: Enrolment in tertiary in public and private institutions [15]

	Country	Enrolment in tertiary Public & Private		Enrolment in tertiary Public	
		2008	2009	2008	2009
OECD COUNTRIES	Australia	1'117,804	1'199,845	1'061,718	1'129,810
	Austria	284,791	308,150	239,439	256,721
	Belgium	401,652	425,219	174,716	182,472
	Canada	M	m	M	M
	Chile	804,981	m	177,210	M
	Czech Republic	392,540	416,847	339,453	356,681
	Denmark	230,707	234,574	M	230,498
	Finland	309,648	296,691	276,639	248,298
	France	2'164,538	2'172,855	1'772,453	1'763,806
	Germany	M	m	2'025,572	M
	Greece	M	m	M	M
	Hungary	413,715	397,679	348,352	333,042
	Iceland	16,631	16,919	13,125	13,289
	Ireland	178,518	182,609	170,177	176,894
	Italy	2'013,856	m	1'873,893	M
	Japan	3'938,632	3'874,224	819,626	817,802
	Republic of Korea	3'204,310	3'219,216	633,556	629,838
	Mexico	2'623,367	2'705,190	1'749,053	1'809,407
	Netherlands	602,286	618,502	M	M
	New Zealand	244,355	263,028	214,865	226,526
	Norway	212,672	219,282	182,944	M
	Poland	2'165,980	2'149,998	1'447,274	1'432,711
	Portugal	376,917	373,002	284,333	282,438
	Slovakia	229,477	234,997	204,931	203,613
	Spain	1'781,019	1'800,834	1'530,124	1'590,025
	Sweden	406,879	422,580	371,810	384,714
	Switzerland	224,469	233,488	185,482	192,692
	Turkey	2'532,622	m	2'392,337	M
	UKiogf Great Britain and Northern Ireland	2'329,494	2'415,217	M	M
	United States of America	18'248,124	19'102,814	13'490,776	13'972,153
PARTNER COUNTRIES	Brazil	5'958,135	6'115,138	1'676,214	1'598,309
	Estonia	68,168	m	10,800	M
	Israel	325,246	342,707	44,868	47,228
	Slovenia	115,445	114,391	102,174	100,673

m: Data is not available

In spite of this, students should investigate private colleges and see how much financial aid is offered before discounting them; they consider attending public versus private colleges, because those are able to cover part or full of their fee tuition.

An important feature linked with reputation is job placement. Morse & Flanigan [3]illustrate this fact with this phrase: "It's the only time in your life where you can really get feedback on your efforts". Graduate students have the expectation that as soon as they finish their studies at college or university, they will be able to find a good job, which will give them the opportunity to grow their professional lives. In order to get an adequate job, they need to gain knowledge that will enable them to function in the workplace. "It is fairly reasonable to say that service and manufacturing industries and other non-profit organizations are the major employers, and who expect that colleges and universities produce well-qualified and trained graduates who could work efficiently and effectively in the jobs for which they have been hired; they need workers who have communication and problem-solving skills and are willing and able to learn their specific jobs quickly and effectively" [7].

Additionally, another factor related to reputation is the Internships done by students. Academic work, structured work experiences, and internships are all valuable components of the career preparation process[13]. Furthermore, internships can be a strong attraction to students in times of shrinking enrollments because they enhance the school reputation and are a vehicle to assist in economic development outreach. Internship programs are positive and offer benefits to all parties involved: the student, the employer, and the HEI"[14].

The general objectives of an internship experience are to prepare students with realistic expectations of their future careers and to provide them with opportunities to polish career search skills, and to gain on-the-job experience. Internships give students many opportunities: they get a chance to apply classroom knowledge and experiences, reflect on individual strengths, weaknesses, and interests, network in the professional arena and familiarize themselves with a career-oriented setting[13].The levels of satisfaction that students relate to in their internships are important, because students considered Internships as a successful way when they are soon-to-be graduate students. Furthermore, they believe that their experiences gained through the internship contribute positively toward their development for careers in retailing. Understanding the factors associated with satisfying internships will enable educators to guide students toward satisfying internships, and retailers to develop optimal internship opportunities[13].

Stern [9] explains that the decision surrounding the choosing of a college is potentially influenced by the marketing and its strategies. The main tactics are the "Toured colleges in a range of 85% and Investigated the college by internet, which earn 20%, especially by Facebook or MySpace page". The relevant information that should be exposed include careers services, facilities on campus, academic

programs of the institution, some information about the number of alumni who become famous after graduation, and the benefits that arise from being part of the prestigious group of students from the university.

Students collect information from a variety of institutions in order to maximize their options, but they will only consider applying to a few of these[2], and finally will attend just one of them. Di'Maria [4] explains that "students are able to collect information when they walk around the campus, observe a class, visit the dorms, and eat in the cafeteria. In this way they are able to talk with current students, faculty, and financial aid and admission officers. It is even of greater interest for the student to be able to visit the school and attend classes in session so they can observe how classes operate. Finally they could join a club or a sport when they attend a meeting or practice; when students are having their college tours, they are able to have their own pre-determined plan of what they want to accomplish and what questions to ask". There is a famous phrase mentioned by Stern [9] in his research, that shows how deeply marketing strategies influence students' choices: "Try on the campus for 24 hours. See how you fit in".

The elements described above are the relevant factors considered by students when they are selecting a university. The study environment and all of the elements required to meet students' needs, have to create a competitive context. Stern [4] mentions that "once a student has gathered information about a school, they evaluate the features and distinguish the important ones from the unimportant ones". Briggs [5], explains that if universities could predict where applicants will come from, and what they will value in a university, the enrollment situation that many universities around the world are facing, will be resolved.

3.2 Part II: Benchmarking

Benchmarking is a management approach used to implement the best practices found in similar industries or even in different industries, aimed at improving the performance of an organization. Currently, benchmarking is widely used to achieve a competitive advantage by implementing best practices in organizations, by evaluating its internal strengths and weaknesses, analyzing comparative advantages of leading competitors, recognizing the best practices of the best performers, and implementing these findings into its strategic plan for achieving a position of superiority [15]. In short, benchmarking could be defined as a main tool delivering improvements by comparing the current and desirable states[16].

There is a definition which could help to understand what Benchmarking is:

"Benchmarking is an ongoing process of measuring and improving business practices against the companies that can be identified as the best worldwide"[17].

This definition emphasizes the importance of improving, rather than maintaining the status quo. It involves searching worldwide for the best companies. Most

marketplaces have international competitors, so best practices are not limited to one country or one geographical location. Information that allows companies to improve their competitive positions must be gathered from best companies, no matter where they are located [17].

Thus, benchmarking represents a process of organizational adaptation where the focus is not simply on copying others, but on learning how to improve organizational performance through sharing ideas. This approach establishes benchmarking as a mechanism that goes beyond being simply a technique or a tool, but rather is a powerful concept with a change agent impacting on behavior modification and developing new ways to manage business[16]. Thus, benchmarking is a learning tool, which identifies organizational competencies and also establishes how these competencies contribute to the sustainability of the exemplar organization [18].

"Companies striving to improve must not accept past constraints. Companies that fail to develop a global perspective will soon be replaced by competitors that have the insight to become global in their perspective. In order to make rapid continuous improvement, companies must be able to think outside the box that is to examine their business from external perspectives. The more innovative the ideas that are discovered, the greater the potential rewards that can be gained from the adaptation of the ideas" [17].

3.2.1 Difference between benchmarking and competitive analysis

The terms *benchmarking* and *competitive analysis* are often confused. The former researches external business sectors for information, whereas the latter shows only how firms compare with their competitors, producing a ranking with direct competitors; it does not show how to improve business processes [17].

Benchmarking provides a deep understanding of the processes and skills that create superior performance [17]. Competitive analyses have helped companies improve their respective market positions. Benchmarking then takes over where this opportunity for improvement ends, because it enables companies to move from a parity business position to a superiority position, by a deep observation of the best practices which can help any company [17].

The type of data for competitive analysis often focuses on meeting some specific industry standard. By comparison, benchmarking focuses on the process that allows such a standard to be not only achieved, but also surpassed. Process enablers and critical success factors must be clearly understood for any permanent improvement to be achieved and sustained. This understanding will require extensive data collection, both internally and from the benchmarking partners [17].

3.2.2 Defining core competencies

As a continuous improvement tool, benchmarking is used to improve core competencies, the basic business processes that allow a company to differentiate itself from its competitors. A core business process may have an impact by lowering costs, increasing profits, providing improved service to a customer, improving product quality, and improving regulatory compliance [17].

"Core competency could be defined as a key business process that represents core functional efforts and is usually characterized by transactions that directly or indirectly influence the customer's perception of the company" [17]. Core competency should impact the following business measures: return on net assets, customer satisfaction, revenue per employee, quality, asset utilization, and capacity [17].

"Prahalad and Hamel in their paper, "*Core Competence of the Corporation*" in 1990, gave a concept of what "core competence" is. They stated that it is a departure *from the outside to inside* thinking of traditional business policy thinkers, who started with environment, and went on to "fit" the organizations' strengths and weaknesses to it. Resources were to be marshaled to achieve what was dictated by the environment. Prahalad et al. emphasized the need for combining these resources and stretching them to new areas and new lengths; combined with an ambitious strategic intent, a firm could do its tasks in a markedly distinct way from its competitors. The trick was to find what a firm could do in a distinct and superior way as compared to other firms *across* different activities or products. This concept has challenged the managers to view their firms as a portfolio of competencies rather than as a portfolio of businesses [19].

3.2.3 Types of benchmarking [17]

There are two types of benchmarking, namely internal (inside the company – enterprise benchmarking; or inside a company group – corporation benchmarking), and external (competition, branch and branch-independent) [20].

3.2.3.1 Internal benchmarking

This is applicable in large organizations with complex organizational structures, since there is a possibility to compare different departments with one another [20]. Typically it involves different departments or processes within a plant or organization. The greatest advantage of this type of benchmarking is that data can be collected easily, and it is also easier to compare data. [17] However, the greatest disadvantage is that it is unlikely to result in any major breakthrough in improvements. Nevertheless, internal benchmarking will lead to small, incremental improvements and should provide adequate return on investment for any improvements that are implemented [17].

3.2.3.2 External benchmarking

External benchmarking requires comparing organizations and productivity with direct competitors (competition benchmarking) or with organizations of the same branch (branch benchmarking) and/or with any organization regardless of the branch (branch-independent benchmarking) [20]. It is divided in two branches:

3.2.3.2.1   Similar industry/competitive

It uses external partners in similar industries or processes. In many benchmarking projects, even competitors are used [17]. Thus, the project tends to focus on organizational measures by meeting a numerical standard, rather than improving any specific business process [17].

3.2.3.2.2   Best practices benchmarking

"It focuses on finding the unarguable leader in the process being benchmarked. It crosses industry sectors and geographical locations, and provides the opportunity for developing breakthrough strategies for the organization. It involves a deep study of business processes outside its organization, adapts or adopts superior business processes, and makes a quantum leap in performance compared to its competitors" [17]. One of the keys to being successful with best practice benchmarking is to define a best practice.

This type of benchmarking is superior because it provides the opportunity to make the most significant improvement; the companies being benchmarked are the best in the market. "Most important, best practice benchmarking provides the greatest potential for achieving breakthrough strategies, resulting in an increase in the company's competitive position" [17].

3.2.4 The benchmarking process

Before embarking on a benchmarking initiative the following pre-requisites should be taken into consideration: first, benchmarking should be seen as just one of the basic pillars of learning organizations because it encourages careful observation and learning from others; second, as a process of learning from others it requires modesty, since without this it is impossible to acknowledge areas where others out-perform your organization; third, benchmarking does not mean uncritical copying, which could be irresponsible when an organization does not understand the essence of its own, individual conditions [20].

1. Conduct internal analysis
2. Identify areas for improvement
3. Find partners

4. Make contact, develop questionnaire, perform site visits [17][17]
5. Compile results
6. Develop and implement improvements
7. Do it again.

3.2.5 Traps to benchmarking [17]

When benchmarking is used properly, it can make a major contribution to the continuous improvement process. However, it can also be completely devastating to a company's competitive position when used improperly. Some of the improper uses of benchmarking include:

1. *Using benchmarking data as a performance goal:* "When companies benchmark their core competencies, they can easily fall into the trap of thinking a benchmark should be a performance indicator. A company receives greater benefits when the tools and techniques used by a partner to achieve a level of performance are understood. This understanding allows the company not only to reach a certain number, but also to develop a vision of how to achieve an even more advanced goal. By focusing on reaching a certain number, some companies may have changed their organizations negatively (e.g., by downsizing or cutting expenses). However, they may have also removed the infrastructure (people or information systems) and soon find they are not able to sustain or improve the benchmark. In such cases, benchmarking becomes a curse" [17].

2. *Premature benchmarking:* "When a company attempts to benchmark before the organization is ready, it may not have the data to compare with its partners. Therefore, someone makes a "guesstimate" that does the company no good. The process of collecting data gives an organization an understanding of its core competencies and how it currently functions. Premature benchmarking will lead back to the first trap--just wanting to reach a number. Companies that step into this trap become "industrial tourists." They go to plants and see interesting things, but don't have enough of an understanding to apply what they see to their own businesses. The end results, then, are reports that sit on shelves and never contribute to improved business processes" [17].

3. *Copycat benchmarking:* "Imitation benchmarking occurs when a company visits its partners and, rather than learning how the partners changed their businesses, concentrates on how to copy the partners' current activities. This practice may be detrimental to a company because it may not have the same business drivers as its benchmarking partners. Also, there may be major constraints to implementing the partner's processes. Such constraints might include incompatible operations, different skill levels of the work force, differences in union agreements, different organizational structures, and different market conditions" [17].

4. *Unethical benchmarking:* "Sometimes a company will agree to benchmark with a competitor and then try to uncover proprietary information while on the site visit

or by use of the questionnaire. Clearly, this kind of behavior will lead to problems between the companies and virtually ruin any chance of conducting a successful benchmarking exercise at a later date. A second type of unethical benchmarking entails referring to or using the benchmarking partners' names or data in public without receiving prior permission. This, too, will damage any chance for ongoing benchmarking between the companies. Even worse, the bad experience may prevent management from ever commissioning further benchmarking exercises with other partners" [17].

3.2.6 Important considerations

1. "It is necessary to explore the tangible and intangible factors that combine to produce a superior performance and involve those people most directly concerned in the activity being examined" [17].
2. "Benchmarks are not the end-all. A benchmark performance does not remain a standard for long. continuous improvement must be the goal" [17].

3.2.7 Purposes of benchmarking

Benchmarking has been used in both private and public sectors, because it is perceived as a tool for increasing productivity and accelerating changes. It facilitates strengths and weaknesses identification and delivers solutions checked by others; it increases competitiveness and improves quality [20].

It has two purposes, namely the direct and indirect. Direct aims include identification of better processes, comparisons with others, identification of strengths and weaknesses with reference to the ideal model, learning from others and the improvement of practices. Indirect aims of benchmarking embrace the development of management skills, overcoming reluctance to ideas from outside the organization, an increase in client satisfaction and gaining advantage over the competition [20].

3.3 Part III: Data Envelopment Analysis (DEA) model

3.3.1 Background and DEA concept

The concept of Data Envelopment Analysis (DEA) dates back to Farrell in 1957. However, the interest seems to have been initiated by Charnes, Cooper and Rhodes in 1978, who proposed DEA as a way of measuring performance in different organizations, the success of which cannot be measured by a single factor such as profit. Thus, DEA began as a new management science tool for technical efficiency analysis of decision-making units (DMUs) [21].

This technique has been applied to a variety of efficiency evaluation problems, where managers wish to conduct a performance evaluation and analyze decision

alternatives [22]. The great variety of applications of DEA includes its use in evaluating the performances of many different kinds of entities engaged in wide range of activities in different contexts in many different countries. Some examples include the measurement of performance of bank branches, hospitals, and universities in performing their education and research functions. Hence, DEA has opened up possibilities for use in cases which have been resistant to other approaches because of the complex, often unknown, nature of the relations between the multiple inputs and multiple outputs involved in many of these activities [23].

The outcome from a DEA analysis is a relative efficiency score for each DMU, calculated in relation to all other DMUs, using the actual measured values for the inputs and outputs. The calculations aim to maximize the relative efficiency score of each DMU, subject to the requirement that the set of weights thus obtained for each DMU must also be feasible for all other DMUs included in the calculations [24]. DEA produces the best practice production frontier, against which each inefficient DMU is evaluated. The source and level of inefficiency for each input and output are identified, determined by comparison to a single referent DMU or a convex combination of other DMUs located on the efficient frontier [21]. The DEA methodology can help bring together a number of performance dimensions, providing a relative evaluation of DMUs on multiple dimensions, simultaneously [25].

3.3.2 How does DEA work?

DEA compares service units considering all resources used and services provided, identifying the most efficient units or best practice units and the inefficient units for which real efficiency improvements are possible. This is achieved by comparing the mix and volume of services provided and the resources used by each unit compared with those of all the other units. In short, DEA is a very powerful benchmarking technique. The most important advantages are that a key attribute is fairness in that the units that are found to be inefficient are located after considering their mix of inputs and outputs. A second benefit is that it provides strong indications of what type and amount of changes in inputs and outputs are needed to make inefficient units efficient" [26].

3.3.3 Decision variables

In DEA, the organization under study is called a *DMU* (Decision Making Unit). The definition of DMU is very flexible in order to be used over a wide range of possible applications. Generically a DMU is regarded as the entity responsible for converting inputs into outputs and whose performance is to be evaluated. In managerial applications, DMUs may include banks, department stores and supermarkets, car makers, hospitals, schools, public libraries and so forth [23].

For example, considering that there are n DMUs: DMU_1, DMU_2, ... , and DMU_n. Some common input and output items for each of these $j = 1,...,n$ DMUs are selected as follows:

1. Numerical data are available for each input and output, with the data assumed to be positive for all DMUs [23].
2. The items (inputs, outputs and choice of DMUs) should reflect an analyst's or a manager's interest in the components that will enter into the relative efficiency evaluations of the DMUs [23].
3. In principle, smaller input amounts are preferable and larger output amounts are preferable so the efficiency scores should reflect these principles [23].
4. The measurement units of the different inputs and outputs need not be congruent. Some may involve number of persons, or areas of floor space, money expended, etc. [23].

3.3.3.1 Inputs

These are the resources or characteristics that are needed to produce its outputs [24].

3.3.3.2 Outputs

These are the products or outcomes all of the resources that will constitute the result of the transformation of inputs [24].

3.3.3.3 Selecting units [27]

The following criteria should guide the selection of units for analysis

- The units to be assessed need to be sufficiently similar so that comparison of them makes sense, but also need to be performing sufficiently differently so that we can discriminate among them
- The units selected should be performing the same tasks with similar objectives
- The number of units to be included in the analysis needs to be sufficiently large so that discrimination between them is possible.
- The units selected are likely to be defined by particular boundaries which might be organizational, physical or regional.

3.3.4 Specifying the input and output model is the most critical aspect of this process

The inputs and outputs to use in an efficiency study are chosen by the basis on which the efficiency of the units is to be assessed. Initially a list should be drawn up

of all the factors which might possibly have a bearing on the performance of the units under consideration. Then it could be reduced to only those factors which are considered the most relevant to the unit performance, so the factors, which have to be eliminated from the list are those [27]:

- For which no data is either readily available or reliable.
- Which do not contribute or relate to the objectives set for the units.
- Which convey the same information as other factors in the list.

A decision has to be made as to which measure best represents a factor chosen for inclusion in the analysis. Qualitative factors can be included in an efficiency study, however, they must have numerical values in order to be used. The normal procedure is to use some measurable surrogate factor which bears a known relation to varying levels of the qualitative factor [27].

3.3.5 DEA modeling

3.3.5.1 Basic DEA (CCR) Model

The most well known DEA model is the one introduced by Charnes, Cooper and Rhodes [28]. It is sometimes called the CCR model, named after its creators. It is a performance measurement technique which can be used for evaluating the relative efficiency of decision-making units (DMUs) on the basis of multiple inputs and outputs. The efficiency of a DMU is defined as the ratio of the weighted sum of its outputs to the weighted sum of its inputs. For each DMU, the DEA method finds the most favorable set of weights [29].

While there are various forms DEA models can take, the most standard forms go under the names "input-oriented" and "output-oriented". The 1978 model by Charnes et al. (CCR) is of the input-oriented variety [24], expressed as:

$$Efficiency = \frac{Output}{Input}$$

It will be shown later that this model is appropriate for those situations where the desire is to determine the extent to which inputs can be reduced and still maintain the same level of outputs[24].

The output oriented model, namely,

$$Efficiency = \frac{Input}{Output}$$

is the model for those environments where inputs may not be easily influenced are non-controllable, but rather it is the output side that managements wishes to improve.

The interpretation of DEA results tends to proceed in the following order:

- Units that are efficient (100% or θ= 1) are relatively, and not strictly, efficient. That is, no other unit is clearly operating more efficiently than these units, but it is possible that all units, including these relatively efficient units, can be operated more efficiently. These units are called DEA Efficient. [26]
- Inefficient units are identified by an efficiency rating of θ<1 in the case of an input-oriented model. These units are strictly inefficient compared to all other units and are candidates for remedial action by management [26].

Speaking to the original CCR Model, assume each member of a set of n DMUs is to be evaluated in terms of the outputs generated relative to the inputs consumed, specifically, let $Y_j = (y_{rj})$, $r = 1,2,\cdots,s$, $X_j = (x_{ij})$, $i = 1,2,\cdots,m$ denote the vectors of outputs and inputs, respectively, held by DMU_j, where $j = 1,2,\cdots,n$ [24]. The Charnes et al. (1978) model for deriving the efficiency score e_o for a given member $j = o$, of the set of n DMUs can be expressed as the solution to a fractional programming problem:

$$(FP_O) \max e_o = \frac{u_1 y_{1o} + u_2 y_{2o} + \cdots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}} \qquad \text{(a.1)}$$

subject to

$$\frac{u_1 y_{1j} + \cdots + u_s y_{sj}}{v_1 x_{1j} + \cdots + v_m x_{mj}} \leq 1 \; (j = 1, \dots n) \qquad \text{(a.2)}$$

$$v_1, v_2, \cdots, v_m \geq 0 \qquad \text{(a.3)}$$
$$u_1, u_2, \dots, u_s \geq 0 \qquad \text{(a.4)}$$

Here the u_r and v_i are output and input multipliers respectively. "The constraints mean that the ratio of "virtual output" vs. "virtual input" should not exceed 1 for every DMU_j. The objective is to obtain weights (v_i) and (u_r) that maximize the ratio for DMU_o, the DMU being evaluated. By virtue of the constraints, the optimal objective value $e_0{}^*$ is at most 1 [23].

Charnes et al. (1978) shows that the above fractional program (FP_o) can be replaced by the following linear program (LP_o) [24],

$$(LP_O) \; max e_o = u_1 y_{1o} + u_2 y_{2o} + \cdots + u_s y_{so} \qquad \text{(a.5)}$$
subject to
$$v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo} = 1 \qquad \text{(a.6)}$$
$$u_1 y_{1j} + \cdots + u_s y_{sj} \leq v_1 x_{1j} + \cdots + v_m x_{mj} \qquad \text{(a.7)}$$
$$(j = 1, \dots n)$$

27

$$v_1, v_2, \cdots, v_m \geq 0 \qquad\qquad\qquad\qquad\qquad \text{(a.8)}$$
$$u_1, u_2, \ldots, u_s \geq 0 \qquad\qquad\qquad\qquad\qquad \text{(a.9)}$$

"Here it is necessary to mention two main theorems, Theorem 1 says that the fractional program (FP$_o$) is equivalent to (LP$_o$) and Theorem 2.2 (Units Invariance Theorem), the optimal values of $max\ e_o = e_o *$ in (a.1) and (a.5) are independent of the units in which the inputs and outputs are measured, provided these units are the same for every DMU (Cooper et al.)" [23, 24]. CCR efficiency can be defined as follows:

1. "DMU$_o$ is CCR-efficient if θ * = 1 and there exists at least one optimal (v*, u*), with v* ≥ 0 and u* ≥ 0" [23].
2. "Otherwise, DMU$_o$ is CCR-inefficient" [23].

3.3.6 The CCR model and dual problem [24]

Let us rewrite the above primal CCR model in the more compact form:

$$(LP_O)\hat{e}_o = \max_{u,v} \sum_{r=1}^{m} u_r y_{ro} \qquad\qquad\qquad \text{(a.10)}$$

subject to

$$\sum_{i=1}^{s} v_i x_{io} = 1 \qquad\qquad\qquad\qquad\qquad \text{(a.11)}$$

$$\sum_{r=1}^{m} u_r y_{rj} - \sum_{i=1}^{s} v_i x_{ij} \leq 0 \qquad\qquad\qquad \text{(a.12)}$$

$$u_r, v_i \geq 0 \qquad\qquad\qquad\qquad\qquad\qquad \text{(a.13)}$$

This problem is generally referred to as the "multiplier model". Its dual referred to as the "envelopment model", is as follows:

$$(DLP_O)\ \hat{\theta} = \min \theta \qquad\qquad\qquad\qquad\qquad \text{(a.14)}$$

subject to

$$\theta x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, \ \forall\ i = 1, \cdots, s \qquad\qquad \text{(a.15)}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro}, \forall\ j = 1, \cdots, m \qquad\qquad \text{(a.16)}$$

$$\lambda_j \geq 0,\ \theta\ restricted\ in\ sign \qquad\qquad\qquad \text{(a.17)}$$

The term θ provides the efficiency score in the input-oriented model. It represents the reduction factor for the inputs. Specifically, the CCR model is referred to as a radial projection model. This name is derived from the fact that inputs are proportionally reduced by θ as shown by (a.15) above, and this reduction takes place along a ray projected through the origin [24] (see Figure 3).

The λ variables identified which efficient DMUs on the frontier are the ones against which the DMU in question is being compared. In the figure DMU A is being compared to DMUs E and D, and only the $\lambda's$ for D and E will be positive and all other $\lambda's$ will be zero (0). The $\lambda's$ for E and D are inversely related to the distances of E and D from A'.
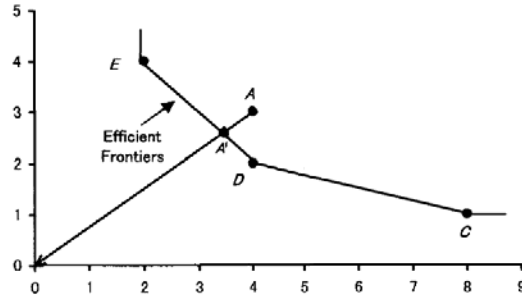
Figure 5: Ray projected through the origin

3.3.7 Cases for CCR model

There are many cases for the CCR model in terms of the number of output and input variables used in the model.

3.3.7.1 Single input and single output

To provide a start to our study of DEA and its uses, we examine a single output to single input case [23]. Assume for example that the single input is the number of employees who are working in a store and the output is sales. The ratio of these two measures the "productivity", often used in management and investment analysis.

Table 5: Single input and single output [26]

Store	A	B	C	D	E	F	G	H
Employee	2	3	3	4	5	5	6	8
Sale	1	3	2	3	4	2	3	5
Sale/Employee	0.5	1	0.667	0.75	0.8	0.4	0.5	0.625

Figure 6: Efficient frontier: Case single input & output [26]

"Representing the data by plotting "number of employees" on the horizontal and "sales" on the vertical axis, we can identify *B* as the most efficient store and *F* as least efficient, see Figure 4. The slopes of the lines connecting points to the origin correspond to the sales per employee for the various stores. The highest such slope is attained by the line from the origin through *B.* This line is called the "efficient frontier." Notice that this frontier touches at least one point and all points are therefore on or below this line. The name Data Envelopment Analysis or DEA, comes from this property because in mathematical parlance, such a frontier is said to "envelop" these points" [23].

"On the other hand, the frontier line designates the performance of the best store (*B)* and measures the efficiency of other stores by deviations from it. DEA identifies a point like *B* for future examination or to serve as a "benchmark" to use in seeking improvements" [23].

Referring to the simplified Figure 5 it can be see that an inefficient DMU such as store A can be raised to a status of "efficient", if it is moved to the frontier [24]. If one were to solve the dual problem (a.14) – (a.17) (the input oriented approach), this would amount to moving from A to A_1. If this move involves reducing the number of employees by 40%, for example, then the optimal θ here would be $\theta = 1 - 0.40$ or 60% [24].

Figure 7: Improvement of DMU A by input reduction [26]

3.3.7.2 Two inputs and one output case

"For this case, taking the previous example, suppose another input was added, namely the area of the store used to sell the products. With this two inputs and one output case, the new figure will shows the plot of *Input x_1/Output y* and *Input X_2/Output y* [23].

30
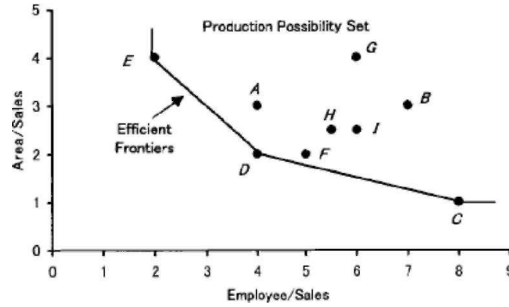
Figure 8: Efficient frontier: Two inputs and one output case [26]

"From the efficiency point of view, those DMUs which use fewer inputs to get one unit output are more efficient. In the figure the line connecting C, *D* and *E* represents the efficient frontier. We can envelop all the data points within the region enclosed by the frontier line, the horizontal line passing through C and the vertical line through *E* [23]. We can also see that many stores come together around *D* and hence it can be said that *D* is an efficient store which is also "representative," while C and *E* are also efficient but also possess unique characteristics in their association with segments of the frontiers that are far removed from any observations" [23].

3.3.8 Output-oriented model [24]

The discussion above pertains to the original CCR model which is an input-oriented structure. The input-oriented model is appropriate in those environments where inefficient units can be rendered efficient by way of input reduction. In settings where it is output expansion not input reduction management wants to undertake, one then reverts to the output-oriented model, which in ratio format is expressed as [24]:

$$min \frac{\sum_{i=1}^{s} v_i x_{io}}{\sum_{r=1}^{m} u_r y_{ro}} \qquad (a.18)$$

subject to

$$\frac{\sum_{i=1}^{s} v_i x_{ij}}{\sum_{r=1}^{m} u_r y_{rj}} \geq 1 \qquad (a.19)$$

$$v_i, u_r \geq 0 \qquad (a.20)$$

This reduces to linear programming format in a manner similar to the input oriented model, specifically:

$$min \sum_{i=1}^{s} v_i x_{io} \qquad (a.21)$$

31

subject to

$$\sum_{r=1}^{m} \mu_r y_{ro} = 1 \qquad \text{(a.22)}$$

$$\sum_{i=1}^{s} v_i x_{ij} - \sum_{j=1}^{m} \mu_r y_{rj} \geq 0 \qquad \text{(a.23)}$$

$$v_i, \mu_r \geq 0 \qquad \text{(a.24)}$$

and its dual

$$max \ \emptyset \qquad \text{(a.25)}$$

subject to

$$\emptyset y_{ro} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 , \ \forall \ r = 1, \cdots, m \qquad \text{(a.26)}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} , \forall \ i = 1, \cdots, s \qquad \text{(a.27)}$$

$$\lambda_j \geq 0, \ \emptyset \ restricted \ in \ sign \qquad \text{(a.28)}$$

It is noted that in the case of the output-oriented model about, $\emptyset$ measures the output expansion factor (in contrast to θ which represents the input reduction factor in the input- oriented model). Referring again to Figure 7, if instead of achieving efficiency by way of input (employee) reduction, management instead strives to increase outputs while keeping its employee level fixed (see slightly modify diagram, Figure 9 to reflect projection in the output direction), then sales would have to increase to point A_2 on the frontier [24]. Note by the way that $\emptyset = 1/\theta$ for the CCR model, hence if $\theta = 60\%$, then $\emptyset = 1.67$ or 167%. Thus, sales would need to grow by 67% in order to render store A efficient [24].

Figure 9: Improvement of DMU A by output expansion

3.3.8.1 The output oriented case for two outputs

Analogous to the two input case above, consider the situation in which we have two outputs, say number of customers and sales per salesman. The efficient frontier for the output-oriented model then consists of the lines connecting B, *E, F* and *G* as shown in the following figure" [23] [23] [26]. It is noted that the radial projection concept can be seen where the ray from the origin through DMU D identifies a point D'. The point D' represents the target that DMU D should aspire to achieve.
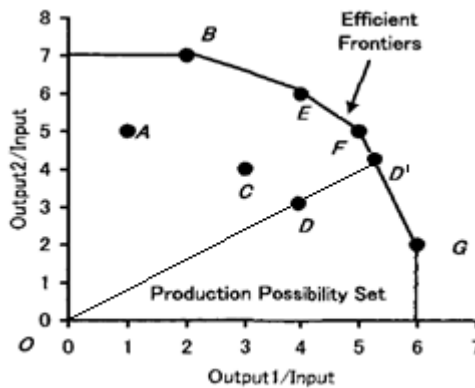
Figure 10: Efficient frontier: One input and two outputs case [26]

3.3.8.2 Restricted multipliers

"In the basic multiplier DEA model, the only restriction on the multipliers applied to inputs and outputs, μ and v, is the non-negativity of the multipliers. This is often replaced by a constraint that the multipliers are greater than or equal to ε, an infinitesimal non-zero number. Requiring the multipliers to be nonzero is significant from a management perspective, as it requires that all inputs and outputs of the unit be assigned some value. If these weights could be zero that units that overuse certain inputs would simply assign a zero weight to those to generate a higher performance efficiency rating. It is tantamount to allowing performance to be measure based only on that things the service unit does well, and ignoring the things it does poorly" [26]. Sometimes, one variable causes more impact than others in the DEA result (one input among inputs or output among outputs), and sometimes it can need more resources than the others. Thus, managers could add a "weight" to those variables which affect the decisions previously mentioned. "Adding this constraint, beyond the basic constraint that the weights be non-zero, causes the DEA analysis to value one variable at least as highly the others. This increases the ability of DEA to identify finer distinctions in efficiency than the basic model and makes the results more powerful in that the inefficiencies that can be remedied may increase with the added constraints" [26].

There are applications in which is necessary to impose restrictions on the multipliers u_r and v_i in the output oriented model (a.21) – (a.24) (It is pointed out that it will be the output, not input oriented model that will be applied in the following case study) [24].

A number of approaches for imposing weight restrictions have been proposed in the DEA literature. The three major types of restrictions are [24]:

1. Absolute weight restrictions
2. Cone-ratio restrictions, and
3. Assurance Region (AR) restrictions

Of these three forms of weight restrictions, the type most commonly applied is the AR restriction as proposed by Thompson et al. [30]. It is this form of weight restriction that is used in the application herein, and the only one we discuss [24].

3.3.9 Assurance region [24]

Assurance Region (AR) constraints take the form

$$\alpha_i \leq \frac{v_i}{v_{io}} \leq \beta_i, \quad i = 1, \ldots, m \qquad (a.29)$$

in the case of input multipliers and

$$\delta_r \leq \frac{\mu_r}{\mu_{ro}} \leq \gamma_r, \quad r = 1, \ldots, s \qquad (a.30)$$

in the case of output multipliers

A constraint such as (a.29) expresses that the weight v_i attached to input i is at least α_i as large as that attached to io (v_{io}), and not more than β_i as large. Example:

$$1 \leq \frac{v_{Employee}}{v_{Assets}} \leq 2.5$$

3.3.10   DEA as a benchmarking tool

Managers are often under pressure to improve the performance of their organizations. To improve performance, they need to constantly evaluate operations or processes related to producing products, providing services, and marketing and selling products. Performance evaluation and benchmarking are widely used methods to identify and adopt best practices as a way to improve performance and increase productivity, and are particularly valuable when no

objective or engineered standard is available to define efficient and effective performance [22].

DEA is a tool which helps the decision maker in the benchmarking effort. It is difficult to evaluate an organization's performance when there are multiple inputs and outputs to the system. The difficulties are even more pronounced when the relationships between the inputs and the outputs are complex and involve unknown tradeoffs. Thus, the DEA methodology helps the performance evaluation and benchmarking exercise under the context of multiple performance measures [22][22, 25]. It provides targets with reference to the best performance for given values of the contextual variables. The targets are those DMUs with the best performance possible, and serve as role-models for each organization [31]. In this way, an inefficient organization could study and adopt operating practices from any efficient organization whether or not it is one of its efficient peers. What makes its efficient peers special is that they are efficient with the very value system that would show the inefficient organization in the best light. Hence, they are likely to offer operating practices and environments compatible with those of the inefficient units. This would make them suitable as role-models which the inefficient organization can emulate to improve its performance [31].

3.4 Part IV: Best practices for attracting students

Organizations around the world have an interest in evaluating the performances of their operations. The terms of "best in class" and "best practice" have become common-place expressions, and as competition grows in many industries, these terms take on even greater relevance. "Performance evaluation and benchmarking positively force any business unit to constantly evolve and improve in order to survive and prosper in a business environment facing global competition. Through performance evaluation, one can (i) reveal the strengths and weaknesses of business operations, activities, and processes; (ii) better prepare the business to meet its customer's needs and requirements; and (iii) identify opportunities to improve current operations and processes, and create new products, services and processes" [32].

Best practices are those which enable a company to become a leader in its respective marketplace. However, best practices are not the same for all companies, so it is determined by business conditions [17]. A complete definition of *best practices* is the following:

"Best practices are good practices that have worked well elsewhere. They are proven and have produced successful results. They must focus on proven sources of best practices" [17]. "However, best practices evolve over time. What was once a best practice in the past may only be a good practice now, and perhaps in the

future even a poor practice. Continuous improvement calls for movement, not business processes that are stagnant" [17].

The following table shows the Types of Best Practices

Table 6: Types of best practices [35]

Type of "best practice"	Description
Icon practice	Practices implemented by admired companies and/or prominent executives - "If IKEA does it, it must be the best"
Award-winning practice	Practices adopted by winners of business excellence awards such as the Malcolm Baldrige National Quality Award - "If the winner does it, it must be the best"
Common practice	Practices that have industry wide diffusion, adoption and acceptance -If everyone else is doing it,it must be the best"
Anecdotal practice	Practices based on anecdotal evidence and widespread sucess stories -"If it worked for them, it must be the best"

3.4.1 Best practices process [33]

Understanding best practices is a four-step process.

1. The first step is the answer to a critical question facing many companies: is "Why capture best practices?" The reasons or objectives for capturing best practices might include [33]:

- Continuous improvements (efficiencies, accuracy of estimates, waste reduction, etc.).
- Enhanced reputation.
- Winning new business.
- Survival of the firm.

The answer to this question also addresses how the company plans to use the best practice, such as for internal use or possibly for external use [33].

2. The next step is to decide where to look for best practices. Typical places to look include:

- Forms, guidelines, templates, and checklists that can impact the execution of the project.
- Forms, guidelines, templates, and checklists that can impact our definition of success on a project.
- Company wide or isolated units.

3. The third step is to decide on the amount of depth to go into the best practice. Should it be generic and at a high level or detailed and at a low level? High-level best practices may not achieve the efficiencies desired whereas highly detailed best practices may have limited applicability [33].
4. The fourth step is the identification of the drivers or metrics that affect each best practice. It is possible to have several drivers for each best practice. It is also possible to establish a universal set of drivers for each best practice, such as:

- Reduction in risk by a certain percentage, cost, or time.
- Improve estimating accuracy by a certain percentage or dollar value.
- Cost savings of a certain percentage or dollar value.
- Efficiency increase by a certain percentage.
- Reduction in waste, paperwork, or time by a certain percentage.

The overall four-step process discussed here can easily lead to a clear definition of what is or is not a best practice [33].

Every company can have its own definition of a best practice and there might even be industry standards on the definition of a best practice. Typical definitions of a best practice might be [33]:

- Something that works;
- Something that works well;
- Something that works well on a repetitive basis;
- Something that leads to a competitive advantage;
- Something that can be identified in a proposal to generate business;
- Something that keeps the company out of trouble and, if trouble occurs, the best practice will assist in getting the company out of trouble.

Generally we view a best practice as "any activity or process that improves a given situation, eliminates the need of other more cumbersome methods, or significantly enhances an existing process. Each best practice is a living entity and subject to review, amendments, or removal" [33].

"In order to manage each best practice consistently, each practice is documented following the best practice profile template, including the description of the practice, the type, the value to the company, and a list of practitioners to use the practice. Each practice documents all of the assets and asset status, and finally all of the practices document the business drivers that have been used to develop the practice" [33].

This definition of a best practice focuses more on the private sector than on the public sector. A comparison of possible incentives for discovery and implementation of best practices in the public and private sectors is the following table.

Table 7: Best practices incentives [36]

Private sector	Public sector
Profit	Minimization of cost
Competitiveness	On-time delivery
Efficiency	Efficiency
Effectiveness	Effectiveness
Customer satisfaction	Stakeholder satisfaction
Partnerships	Sole-source procurement

3.4.2 Best practices characteristics

1. "Best practices may not be transferable from company to company, nor will they always be transferable from division to division within the same company" [33].
2. "Best practices need not be overly complex. Even though some best practices seem simplistic and common sense, the constant reminder and use of these best practices lead to excellence and customer satisfaction" [33].
3. "Properly designed forms, checklists, and templates can become best practices if they are used correctly" [33].
4. "Best practices can support other processes or other processes can support best practice" [33].

3.4.3 Levels of best practices

Best practices come from knowledge transfer and can be discovered anywhere within or outside of your organization. This is shown in the following figure:
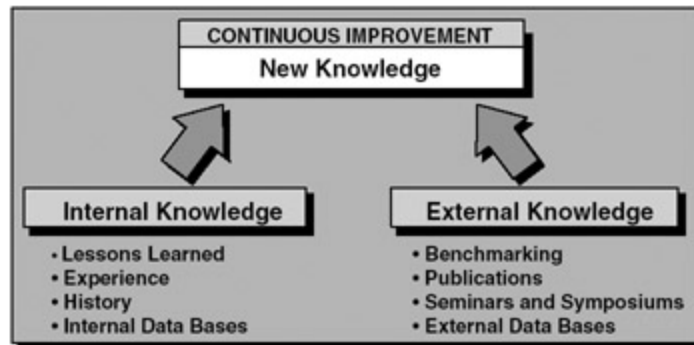
Figure 11: Knowledge transfer

3.4.4 Journey to excellence

"Every company has its own forces, or driving forces, that force the company to embark upon a journey for excellence in project management. Some companies complete the journey in two or three years, while others may require a decade or more. Each company takes a different path, but they all achieved some degree of excellence in project management" [33].

3.4.4.1 The driving forces for excellence

3.4.4.1.1 Capital projects

All organizations spend great amounts each year on capital projects. Without good estimating, cost control or schedule control, capital projects can strap the organization's cash flow, force the organization to lay off workers because the capital equipment either was not available or was not installed properly, and irritate customers with late shipment of goods. In non-project-driven organizations and manufacturing firms, capital projects are driving forces for maturity [33].

3.4.4.1.2 Customer expectations

Today, customers expect not only a quality product or services but also the organization needs to manage this activity using sound project management practices. This includes effective periodic reporting of status, timely reporting of status, and overall effective customer communications [33].

3.4.4.1.3 Competitiveness

The third common driving force behind project management is competitiveness. The most common form of competitiveness is when two or more companies are competing for the same work [33].

3.4.4.1.4 Executive understanding

"A fourth driving force toward excellence is executive buy-in. Visible executive support can reduce the impact of many obstacles. Typical obstacles that can be overcome through executive support include:

- Line managers who do not support the project.
- Employees who do not support the project.
- Employees who believe that project management is just a fad.
- Employees who do not understand how the business will benefit.
- Employees who do not understand customers' expectations.
- Employees who do not understand the executives' decision" [33].

3.4.4.1.5 New product development

The new product development process encompasses the time it takes to develop, commercialize, and introduce them to the market. In certain industries, new product development is a necessity for survival because it can generate a large income stream for years to come, and with product enhancement, the duration can extend even further [33].

3.4.4.1.6   Efficiency and effectiveness

"Improvement in overall efficiency and effectiveness of the company is difficult. It often requires change in the corporate culture, and culture changes are always painful. The speed at which such changes accelerate the implementation of project management often depends on the size of the organization" [33].

Sometimes, there are additional driving forces:

- Increase in project size mandated by the necessity to grow.
- Customers demanding faster implementation.
- Customers demanding project management expertise for some degree of assurance of success completion.
- Globalization of the organization mandated by the need to grow.
- Consistency in execution in order to be treated as a partner rather than as a contractor.

CHAPTER 4: CASE STUDY

4.1 Applying a Restricted Multiplier DEA Model to Escuela de Negocios, Ciencias Sociales y Humanidades (ENCSH) at ITESM, a Higher Education Institution in Mexico

Instituto Tecnológico y de Estudios Superiores Monterrey (ITESM), is a of higher education institution that prepares its students to become responsible citizens and promote development of their communities. They promote humanistic values in them, international vision and entrepreneurial culture. It has 31 campuses in Mexico and in several countries with headquarters and liaison offices [34].

This institution is characterized by many factors which are attractive for students and other stakeholders. This affirmation can be confirmed by the number of students enrolled. Data obtained from Annual Reports support this statement:

Table 8: Total student enrolment at ITESM

Year	Winter semester enrolment	Fall semester enrolment
2005	16242	17055
2006	16276	17641
2007	16070	17576
2008	15663	17148
2009	15714	16979
2010	15789	17092
2011	14614	

(The data was obtained from the Annual Report from ITESM, except the 2011's data, which was given by the department of ENSCH).

The population under examination is focused on the students at ENCSH at ITESM. The first data related to this research is collected from the last 3 semesters. The following chart shows the number of student enrolled to this school:

Table 9: Total student enrolment at ENCSH from 2010 to 2011

2010		2011
Winter	Fall	Winter
5745	5795	4935

It is important to mention that this study only involved an internal analysis of the university. In short, it only includes those processes, features and offers given by the university to their clients, the students, without considered external elements,

such as environmental, political or cultural features which aren't able to be changed by the institution.

ENCSH represents a relevant population because of the importance and reputation which ITESM has gained. This is verified by the results of the QS University Ranking Latin America (QS Latur) that was published in October, 2011. In this publication ITESM is ranked No. 7 among 200 universities in Latin America.

Additionally, in reporting on the world best universities, the U.S. News and World Report (USN & WR) rank ITESM in 176 place in terms of careers of Social Sciences and Business students, which includes the ENCSH.

Table 10: Ranking of ITESM in terms of social and business faculty

Year	Ranking
2005	203
2006	256
2007	241
2008	243
2009	365
2010	232
2011	176

4.2   Results obtained by the survey applied to ENCSH Students

In order to examine the features considered by students when they are analyzing all the alternatives to select a HEI, a survey was developed. First of all, a literature review was done involving surveys students. The purpose of these surveys was to collect data involving criteria that students used in selecting a university to attend. A sample survey was selected for use in the current case study. Some modifications were made to adapt it to the aim of this research.

When all the questions and all the parameters needed were embodied in the questionnaire, it was submitted to *Google Docs* tool, which creates the actual survey. In this way, all the students were able to access to the survey without any constraints such as the number to the responses.

The questionnaire was delivered in a Spanish version to all the students from ENCSH at ITESM, Campus Monterrey. They were able to accede to it by going through the following link:

http://bit.ly/w1QQeZ

The Appendix 7.1 contains a copy of the questionnaire used in the data collection process of the alumni at ENCSH.

In order to examine the match among the literature review and the interests of the students at ENCSH, the following tables will show all the responses and the results obtained of this case study.

Table 11 contains the population under study from the ENCSH and their field of study. The total number of respondents is 400 students, from different careers. See Figure 12.

Table 11: Students and their career at ENCSH participating in the study

Major	Major	Frequency	Percentage	Accumulative percentage
Lic. en Psicología Organizacional	LPO	15	3.75	3.75
Lic. en Contaduría Pública y Finanzas	LCPF	57	14.25	18
Lic. en Negocios Internacionales	LIN	81	20.25	38.25
Lic. en Mercadotecnia	LEM	63	15.75	54
Lic. en Administración Financiera	LAF	2	0.5	54.5
Lic. en Administración de Empresas	LAE	28	7	61.5
Lic. en Creación y Desarrollo de Empresas	LCDE	17	4.25	65.75
Lic. en Relaciones Internacionales	LRI	33	8.25	74
Lic. en Ciencia Política	LPL	11	2.75	76.75
Lic. en Lengua y Literatura Hispánicas	LLE	11	2.75	79.5
Lic. en Ciencias de la Comunicación	LCC	11	2.75	82.25
Lic. en Medios de Información	LMI	11	2.75	85
Ing. en Producción Musical	IMI	0	0	85
Lic. en Economía	LEC	52	13	98
Lic. en Derecho	LED	8	2	100
Lic. en Derecho y Finanzas	LDF	0	0	100
TOTAL		**400**	**100**	
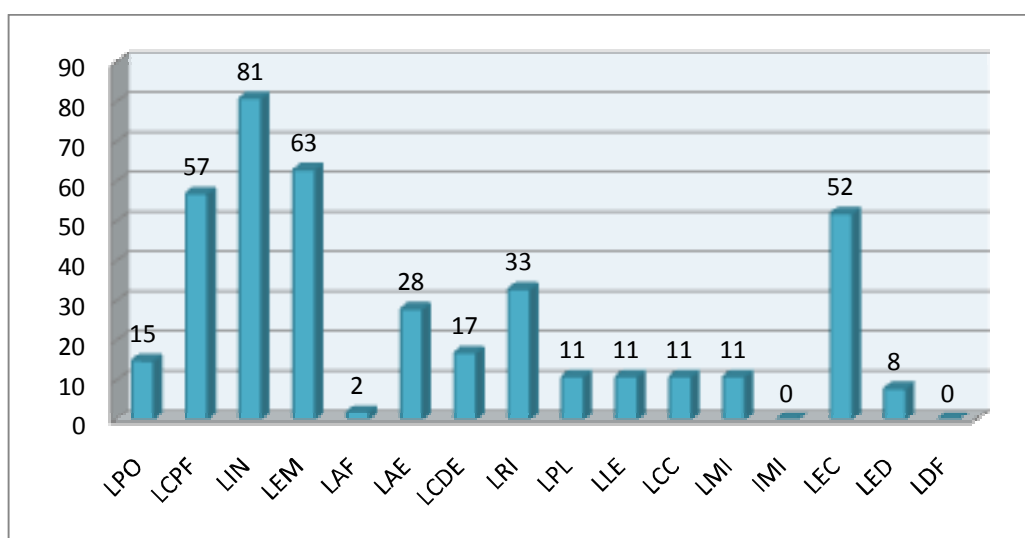
Figure 12: Population under study and their majors

In order to determine all the features, factors and characteristics considered by students over time, this survey was applied to all levels of enrolment of students participating in the study, from the first to the ninth semester of their careers. Table 12 has the information about the semester of the students participating in the study.

Table 12: Semester of the students participating in the study

Semester	Frequency	Percentage	Accumulative percentage
First	172	43	43
Second	7	1.75	44.75
Third	44	11	55.75
Fourth	10	2.5	58.25
Fifth	41	10.25	68.5
Sixth	15	3.75	72.25
Seventh	47	11.75	84
Eighth	10	2.5	86.5
Nineth	54	13.5	100
TOTAL	**400**	**100**	
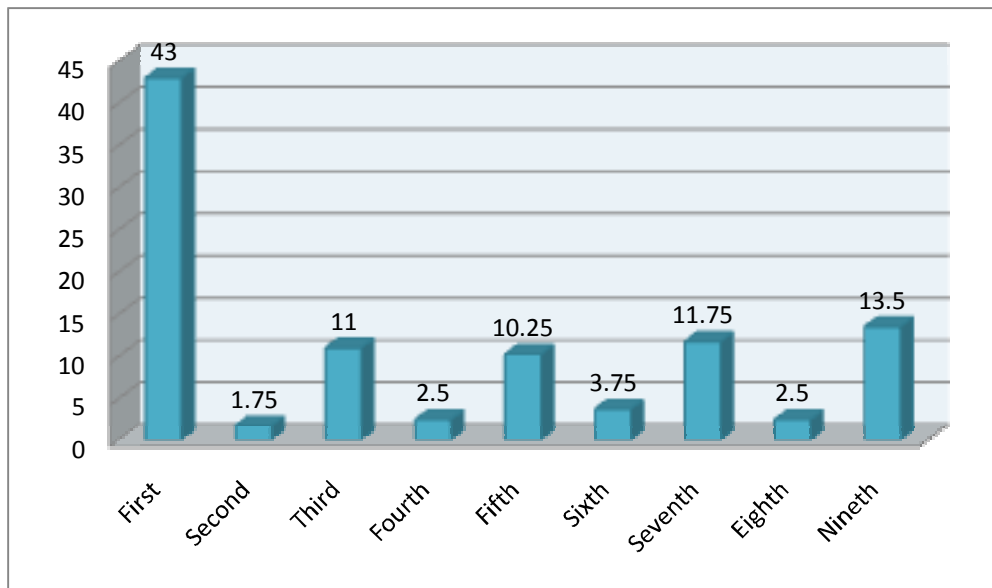
Figure 13: Percentage of the enrolment level from students participating in the study

In addition to considering their criteria for evaluating an institution, they were asked as well to rank, according to their criteria, what was important and how they assess the higher education institutions. In this section they had to rank from 1 to 5, where 1= strongly disagree 5= strongly agree.

Table 13 contains the criteria of students about how they evaluate the institution.

Table 13: Criteria for evaluate an institution

	1		2		3		4		5	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
I used several ways of evaluating institutions before making my final decision	51	13	49	12	57	14	103	26	140	35
I did some detailed comparisons of institutions before making my decision	60	15	46	12	68	17	96	24	130	33
I researched on the institutions in order to find out what is bad as well as what is good about them	58	14	37	9	56	14	99	25	150	38
For me it is important to go on an institution tour before deciding on an institution	97	24	66	17	84	21	70	18	83	21
I contacted the institution by web pages or callings in order to get some information	59	15	39	10	56	14	70	18	176	44
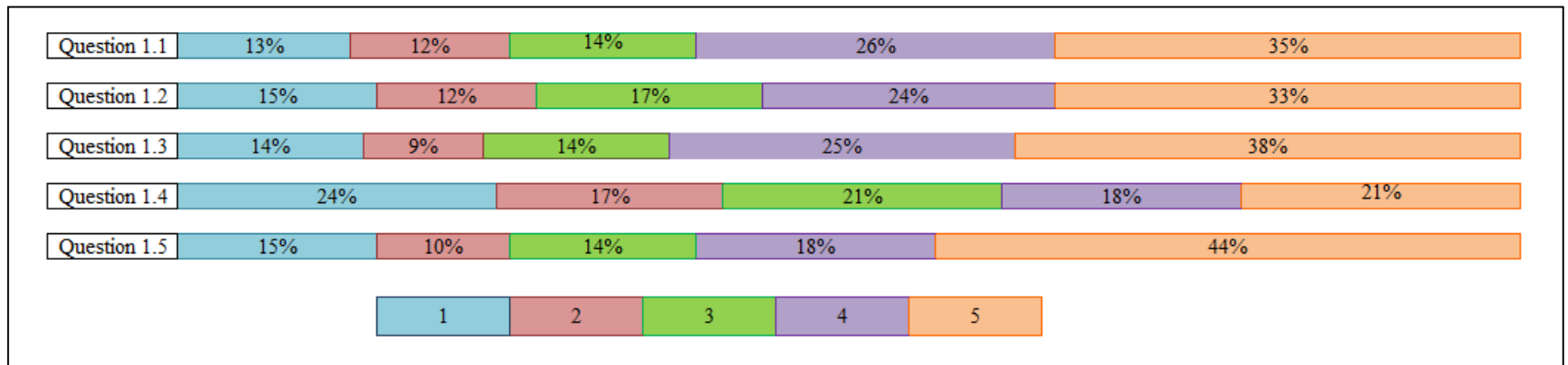
Figure 14: Frequency of the criteria on how students evaluate an institution

Tables 14, 15 and 16 show the list of universities which were analyzed by the students, and also it gives an idea of the competitors of ITESM.

Table 14: List of institutions from which students collected information about

Higher Education Institution	Count	Percentage of responses
Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)	392	98
Universidad Autónoma de Nuevo León (UANL)	95	24
Universidad de Monterrey (UDEM)	201	50
Universidad Metropolitana de Monterrey (UMM)	1	0
University in Mexico	93	23
University in United States	84	21
University in Canada	18	4
University in Latin America	12	3
University in Europe	19	5
University in Asia	2	0
University in Africa	1	0
University in Oceania	2	0
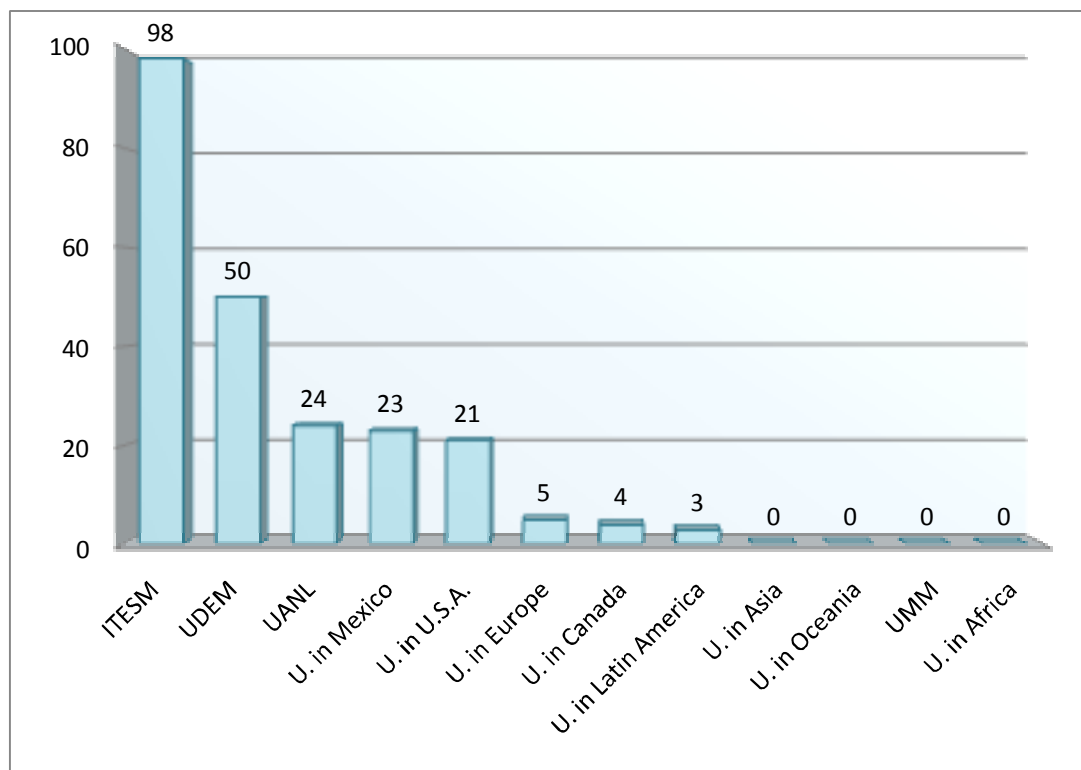
Figure 15: Percentage of the institutions from which students collected information

Table 15: List of other worldwide universities from where students collected information

List of universities in other places different from Monterrey - Mexico		
Mexico	**United States of America**	**Latin America**
Universidad Nacional Autónoma de México	Yale University	Universidad Autónoma de Buenos Aires
Instituto Tecnológico Autónomo de México	Harvard University	Escuela de Negocios Fundacao Getulio Vargas
Universidad del Valle de México	University of Chicago	Universidad de Palermo
Universidad de América de Puebla	Stanford University	Universidad Católica de Chile
La Salle	Columbia University	Universidad de Belgrado
Universidad Autónoma de Ciudad Juárez	UT Austin	Universidad de Los Andes
Universidad del Norte de Tamaulipas	UT Houston	Universidad Gabriela Mistral
Universidad Iberoamericana	Georgetown University	Universidad de San Andrés
Universidad Autónoma de Tamaulipas	University of Texas	Universidad del Pacífico
Universidad de Vasco de Quiroga	Pan American	Universidad Católica de Perú
Universidad Autónoma de Guadalajara	South Texas College	Universidad Nacional de San Marcos
ITESO	Texas A&M	Universidad San Francisco de Quito
Universidad de Anáhuac	Incarnate Word TX	
Universidad de Chihuahua	Babson College	**Europe**
	UTB	Universidad de Navarra
Canada	Loyola University	University of Essex
University of Toronto	University of Notre Dame	Universitat de Barcelona
College LaSalle	University of San Diego	Universidad Complutense de Madrid
University British of Columbia	Georgia University	Barcelona Business School
York University	University of Arizona	Universidad de Mónaco
University of Waterloo	Saint Edwards University	Science Politiques de Aix-en-Proven
	New York University	
Africa	Santa Barbara University	**Asia**
Universidad Berchingham en Rocklands	Central Michigan University	Kanshug Taiwan
	Rutgers University	Sun-Yatsen University
Oceania	Wharton School of Business	United Arab Emirates University
University of Queensland	Princeton University	

Table 16: List of institutions to which students applied for

Higher Education Institution	Count	Percentage of responses
Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)	396	99
Universidad Autónoma de Nuevo León (UANL)	25	6
Universidad de Monterrey (UDEM)	90	22
Universidad Metropolitana de Monterrey (UMM)	0	0
University in Mexico	44	11
University in United States	28	7
University in Canada	5	1
University in Latin America	3	1
University in Europe	1	0
University in Asia	3	1
University in Africa	0	0
University in Oceania	2	0
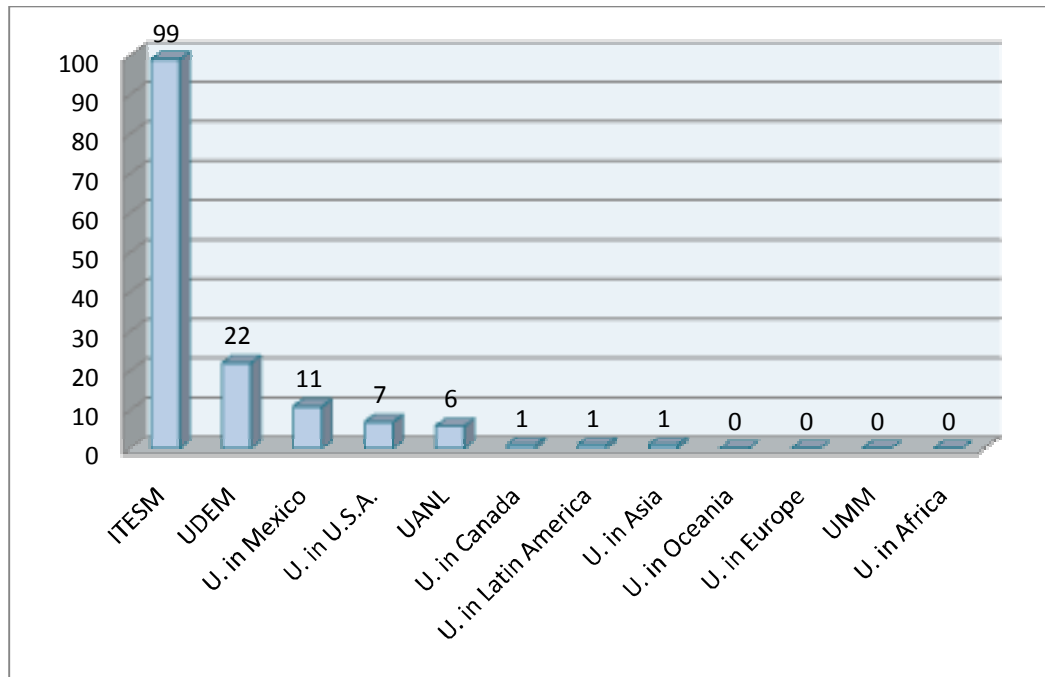
Figure 16: Percentage of students ' preference of the institutions to which students applied for

Table 17 illustrates all the information that was researched by the students when they were evaluating the institutions.

Table 17: Important information collected by students

Information	Count	Percentage
General Information Brochure	278	69
Information about overseas study programs	353	88
Information about sporting programs and facilities	76	19
Information about artistic programs and facilities	84	21
Admissions policies and procedures	237	59
Information about fees and scholarship information	288	72
Records of academic achievements	82	20
Information about institution academic research record	21	5
Information about courses (degrees or diplomas) offered	104	26
Information about social programs and facilities	35	9
Student welfare programs and facilities	28	7
Other	17	4
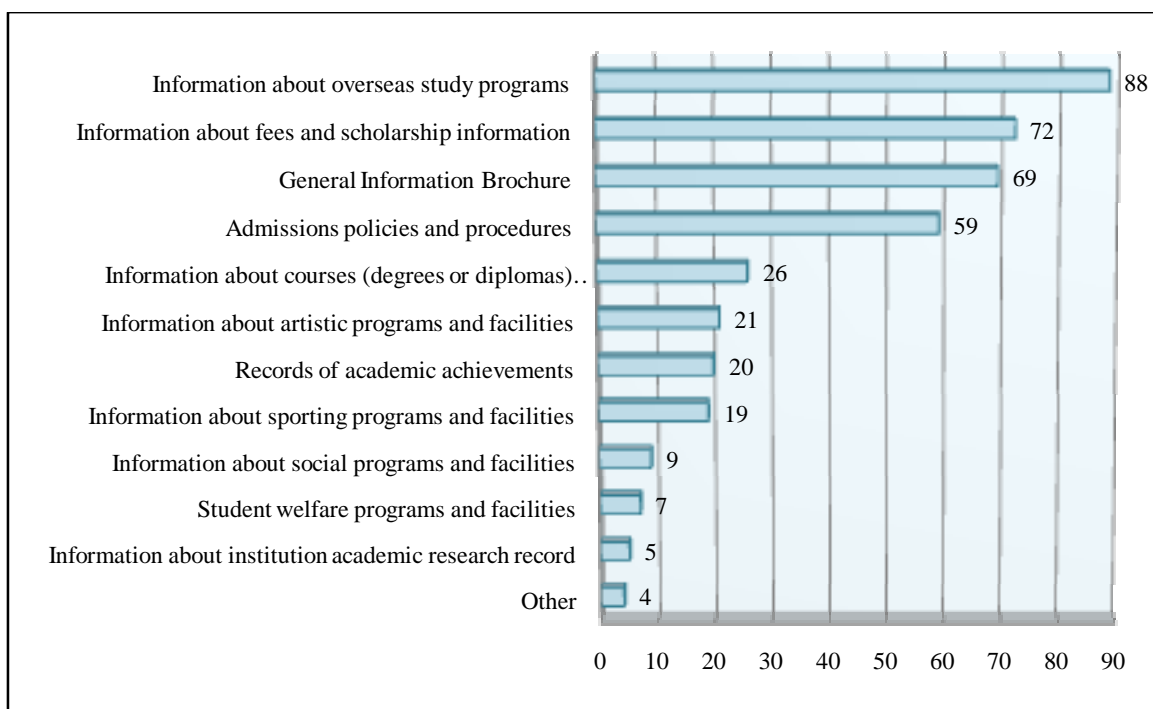
Figure 17: Percentage of the information considered important for students

Table 18 illustrates the frequency and percentage of the most important issues considered relevant for students at the moment of their choice.

Table 18: Students' criteria about the most important issues considered when selecting a university

Features	1		2		3		4		5	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Fees and cost associated with attending	32	8	16	4	60	15	71	18	221	55
Image or reputation of the institution	15	4	10	2	21	5	55	14	299	75
Location of the university	44	11	46	11	67	17	95	24	148	37
Degree programs offered	20	5	18	4	81	20	118	30	163	41
The difficulty of the academic program of study (it was hard)	58	14	45	11	90	23	109	27	98	25
Educational facilities such as the library, classrooms and labs	29	7	34	9	108	27	112	28	117	29
Prestige of course of study	17	4	17	4	40	10	96	24	230	58
Educational opportunities such as exchange programs, internships, research	24	6	18	4	43	11	81	20	234	59
Prestige of institution teaching staff	27	7	16	4	58	14	116	29	183	46
Opportunities to meet people and societies	24	6	39	10	80	20	100	25	157	39
Job placement programs and the ability to get a good job on graduation	34	9	50	13	69	17	75	19	172	43
Availability of part time study options	91	23	53	13	111	28	71	18	74	18
Availability of financial aid and scholarship	43	11	26	7	47	12	46	12	238	60
Availability of student welfare programs	86	21	77	19	112	28	63	16	62	16
Availability of on-line courses	153	38	66	16	84	21	42	11	55	14
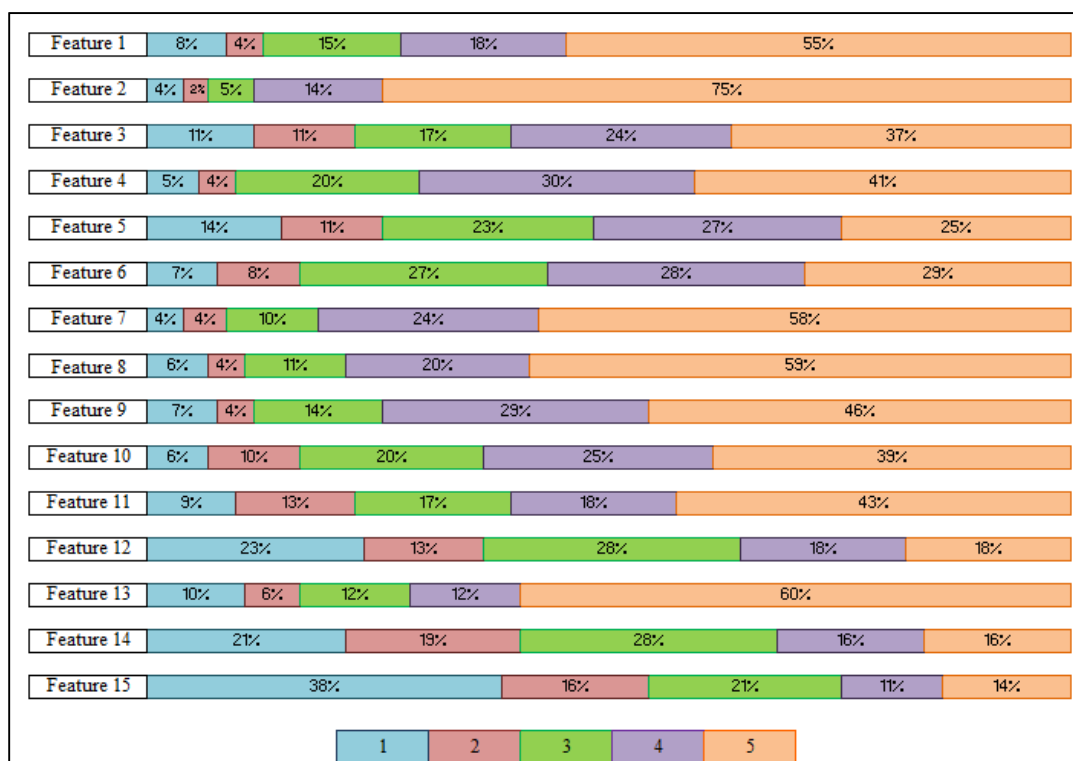
Figure 18: Frequency of the most important issues considered by students

In the Table 19 it is show the frequency of the 5 more important issues considered by students when they compare an Institution to others.

Table 19: Frequency of how issues were considered by students when evaluating an institution

Features	Count	Percentage
Fees and cost associated with attending	189	47
Image or reputation of the institution	335	83
Prestige of course of study	150	37
Degree programs offered	110	27
The difficulty of the academic program of study (it was hard)	61	15
Educational facilities such as the library, classrooms and labs	95	24
Location of the university	150	37
Educational opportunities such as exchange programs, internships, research	241	60
Prestige of institution teaching staff	146	36
Opportunities to meet people and societies	118	29
Job placement programs and the ability to get a good job on graduation	127	32
Availability of part time study options	24	6
Availability of financial aid and scholarship	191	48
Availability of student welfare programs	13	3
Availability of on-line courses	7	2
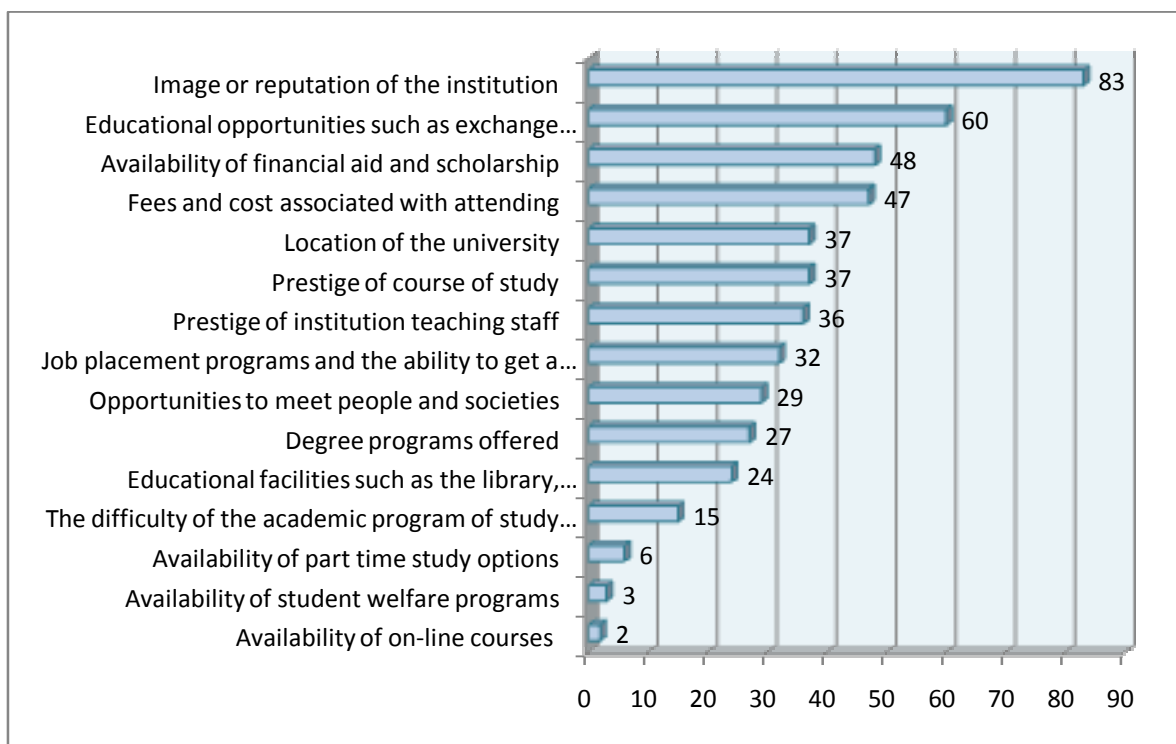
Figure 19: The most important issues considered by students when choosing a university

Students were asked to identify from which media they got promotional information about the Institution, and the people they spoke to that may have influenced their decisions. Tables 20 and 21 show the various media, and other stakeholders, from whom they obtained promotional information regarding their university choice.

Table 20: Media from which students got promotional information about institutions

Promotional information about institutions	Count	Percentage
Newspaper articles (not advertising)	72	18
Advertising	102	25
Information provided by professionals	89	22
The internet	305	76
A handbook on institutions such the "Good Universities Guide"	108	27
Advertising in magazines or journals	58	14
School visits to institutions	132	33
Visits to your school by institutional representatives	138	34
Careers information collected from school or work	78	19
Other (please specify)	29	7
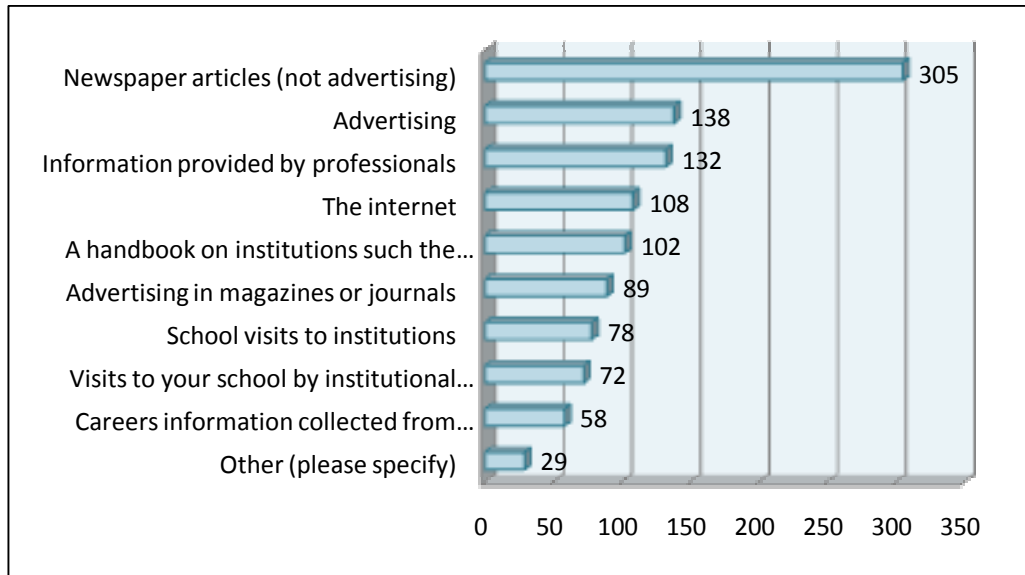
Figure 20: Frequency of the media used by students to get promotional information about institutions

Table 21: Stakeholders influencing students' decision

People	Count	Percentage
Parents, brothers and/or sisters	364	91
Friends, classmates and neighbors	153	38
Careers and counselors, teachers and staff at school	83	21
Teacher and staff of the HEI	46	11
Students enrolled at the current institution	93	23
Training and development staff for work	7	2
Others	19	5
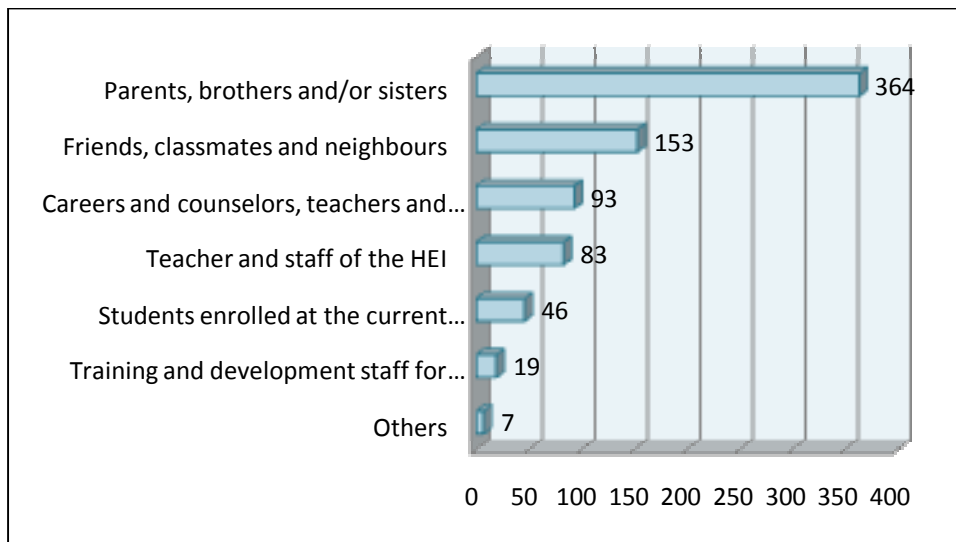
Figure 21: Frequency of other stakeholders influencing students' decision

Based upon the respective analyses of the data collected from the survey, there is evidence that the most important features or characteristics considered by the students, when they were looking for and selecting a university, are image and reputation from the university, educational opportunities, financial aid and scholarships, fees and costs of education, prestige of the course and teaching staff and job placement. Additionally, to these features we might add another important characteristic, namely the admission rating, in that students always consider the average of students admitted to an institution, in order to avoid a negative response from the institution. The combination of these factors generates value not only for the student and their family, but also for the labor market.

4.3   Inputs and outputs considered for the case under study

In order to apply the DEA model to higher education, it is very important that the variables included in the model should be factors influencing the choices of applicants. In order to be more attractive for students, it is well know that they focus on the prestige of the institution in terms of their opportunities to be part of the labor market, during and after their student life, such as student internships and job placements. Other important factors for choosing a university are the academic quality (particularly teaching reputation and available academic and support facilities), entry requirements, costs of study and financial aid availability. In the following section, the most common variables considered by students around the world will be described.

4.3.1.1 Inputs

4.3.1.1.1   Academic rating

Franek et al. (2011)[35], includes this variable in the ranking of the Best College. On a scale of 60-99, this rating is a measure of how hard students work at the school and how much they get back for their efforts. Factors weighed included how many hours students reported that they study each day outside of class, student' assessments of their professors' teaching abilities and of their accessibility outside the classroom and the quality of students the school attracts as measured by admissions statistics.

"Accessing higher education has resulted in an increasing demand for information on academic quality, and has led to the development of university ranking systems or league tables in many countries of the world. College education is a very important purchase as well as expensive decision in one's life; for that reason, many students and their families are seeking information that will help them make informed choices in the selection of a university and/or an academic program" [36].

"Its (academic rating) construction depends on perceived quality and market prominence definition of reputation as *stakeholders* perceptions about an organization's abilities to create value relative to competitors". This is determined through the interactions and interrelationships among multiple attributes, both internal and external to the institution. Academic reputation has been labeled variously as quality or prestige and has been linked with phenomena such as the presence of graduate programs, faculty research productivity, faculty size, and affiliation with an elite university. This value is derived from interconnections of factors that lead to competitive advantage, and ultimately, performance superiority [37].

4.3.1.1.2   Admission rating

Franek et al. (2011) [35] explains that this variable, in the range of 60-99, measures how competitive admission is at the school. This rating is determined by several factors, including the class rank of entering freshmen, test scores, and percentage of applicants accepted.

"The rankings suggest that one of the leading determinants of a good university is the quality of its incoming students. Quality of incoming students is measured by secondary school grades as well as by university entrance tests. There are some arguments that "students are enriched by the input of their peers" and therefore if a university is able to attract the best students (or international and out-of-province students), then it must be a good university. Ranking all universities using measures of student selectivity based upon median entering test scores therefore provides information of little value to the majority of university applicants" [36].

Within the context, the Institutional selectivity is a measure of admissions competitiveness (Barron's, 2000). Selectivity scores provide information on the general academic qualities needed for admittance into a specific institution. Colleges and universities with high selectivity ratings enroll students with higher standardized test scores, high school grade point averages and high school rank, than is true of those institutions with lower selectivity ratings and as a result, may have higher retention and graduation rates [38].

Similar to the academic rating, reputation plays an important role in the Admission rating, because a stronger reputation is associated with a lower acceptance rate, hence better selectivity, higher yields and better students. Prior studies have identified that these variables have an important influence on students choices in selecting schools to attend [37].

Institutional research can enhance an institution's competitive advantage through admission research by comparing the characteristics of inquirers who apply with those who do not; by documenting trends in the characteristics of applicants; and by conducting studies of accepted students, comparing those who

matriculate with those who do not. Retention studies are an opportunity to link admission criteria to student performance in college [39].

4.3.1.1.3   Financial rating

On a scale of 60-99, this rating is a measure of the financial aid the school awards and how satisfied students are with the aid they receive. It is based on school-reported   data on financial aid and students' responses to the survey question, "If you receive financial aid, how satisfied are you with your financial aid package" [35].

Many studies have found that there were strong direct relationships between high performance of the enrolled students, and institutional support. [38] What is more, the availability of funds to meet tuition and other college-related expenses not only impacts a student's decision to attend college, but also affects, to a great extent, the choice of college made by that student, underscoring its role in different student decisions [40].

Research regarding student financial assistance indicates that the impact of aid is significantly related to student factors and outcomes such as academic achievement, educational commitments, student engagement, and persistence to graduation[40].

The relationship between financial aid and enrollment is complex. Their findings helped to further establish that financial aid has a positive impact on student enrollment. Although prior evidence indicates that a positive relationship exists between financial aid and enrollment rates, the research also indicates that low-income students are more reluctant to borrow monies to finance their education than middle- or upper income students [40]. However, financial aid frees students to fully engage in many activities on their campuses. In other words, students can become fully integrated into the social, educational, cultural, political realm of their institutions by providing them with the time to interact with peers and participate in all campus functions and activities. In short, financial assistance allows time for the student to make use of academic resources that could have an impact on their academic performance [40].

4.3.1.1.4   Percentage of students who graduated in the top 25% of their class

This group consists of those students for whom class rank was reported, that is the percentage of entering freshmen who ranked in the top quarter of their high school classes [35]. For many years, universities have actively competed for the best and brightest students. This is the main reason why institutions are

increasingly focusing their recruitment efforts on academically talented students [41].

"The conventional wisdom appears to be that, although the intellectual progress of all college students is important, the attitudes and accomplishments of the most talented students help to improve an institution's academic atmosphere and differentiate a university from its peer institutions" [41].

4.3.1.2 Outputs

4.3.1.2.1   Students with internship

As economic and social life becomes more globally connected and challenging, there is increased need to develop societies with the capacity to connect, engage, and prosper internationally. Countries around the world are forming connections and agreements to grow trade; facilitate the mobility of people, goods, and services; and address environmental challenges. Higher education institutions have implemented various initiatives to promote the skills, knowledge, and intercultural understandings for international engagement. Consistent with trends in higher education, student exchange agreements with overseas universities have been a major component of institutions' internationalization strategies. Exchange partnerships between universities enable students to study overseas as part of their degree program without increasing their undergraduate tuition fees. Typically, students study abroad on exchange for either one semester or for a full year [42].

However, students feel that there is a lack of incentives for academic faculty to promote and support study abroad, so this situation is responsible for making students fail opportunities and sometimes they don't become competitive because they get a narrow view and they lose the opportunity to get foreign language skills. For that reason, it is very important to promote initiatives such as funding incentives, collaborative partnerships with other countries, and institution-wide frameworks and strategies, and especially students will be attracted to the Institution because they will be able to experience a great enhancement of their personal and career development by the internationalization of their education, because it will enhance intercultural competence and international understandings in the larger student population [42]. Studies have emphasized that the countries that might attract the greatest interest to students are United States, Canada, England, Australia, and Western Europe [42].

Among the most powerful reason why students want to make an internship is because they could get personal growth and independence, they could learn about other cultures, career orientation, academic interest or growth and other approaches to teaching and learning , international curriculum and international networks and especially the possibility to break up the time of a double degree

[42]. This situation also benefits the institution because international initiatives ensure quality of education [43].

4.3.1.2.2   Job placement

Graduate employment measures are attractive outputs, but these indicators are still vulnerable to criticism. The decision to attend higher education depends on the ratio of marginal cost to marginal return expected from higher education in term of job placement [44]. Higher starting salaries are an important metric of institutional success. From a student's perspective, starting salary helps to drive the decision to enroll in a HEI. Prospective students will seek out the most prominent program that they can be admitted to, in order to maximize future income [37]. In short, alumni are satisfied with the college education when they are better prepared for employment [39], and when they feel that the costs of their education will give great returns on their investment [44].

Differences in the labor market outcome of education may affect educational choices since they influence the expected benefit which might be obtained from the acquisition of further education. The estimation of these labor market expectations is based on the assumption that people observe the current labor market situation of "comparable" people of the previous generation and people with the same observed characteristics, and expects their own situation to become similar. Labor market expectations appear to have a significant impact on enrolment decisions. The absolute wage an individual can expect to earn might affect the probability of attending a tertiary level institution in different ways [44]. On the other hand it is very important that all the students get a superior education, because if they "want to compete well in the job market, graduates must be equipped with the skills and knowledge required by employers" [45].

For HEIs there are some publicly available data, especially for the American universities. This situation is because most of the time, American higher education institutions are constantly evaluating their performance and their characteristics so that they can be part of the ranking, and be attractive for students; however although ITESM is within the ranking of the QS World University Ranking it doesn't include all the data. The solution to this problem is to employ internal data, collected by the survey, especially the two last questions (See Appendix 7.1). Further, other data collected was provided by the ENCSH.

4.4   Efficiency modeling

This situation shows a great opportunity to analyze it by DEA, with an important objective, namely identifying the most efficient universities in order to benchmark ENCSH against other schools that compete in the education market. For that, the results from the literature review and the survey are the base line, and also will

contribute to developing this benchmark. This will be an important factor in establishing best practices for attracting students and encouraging them to be part of the institution.

In this case study, the variables considered are listed in two main parts, Inputs and Outputs. As we mentioned before, the process of selecting pertinent variables is critical for analyzing data and affects the validity of a study.

The Inputs considered are:
- Academic Rating
- Financial Rate
- Admission Rating
- % Top 25 in class

Outputs considered are

- Students with internship
- Job Placement

This proposal of this application is to create a causal relationship among inputs and outputs, both including the features or factors attractive for students. College attributes both fulfill and affect student decisions: students who wish to attend college will presumably select colleges they are likely to attend. College actions, such as admission or financial-aid decisions, can also fulfill student decisions, but college actions can be responsible for changing students' minds.

This situation provides an opportunity to make a thorough evaluation through DEA, with efficiency scores being the result of its application. This analysis will suggest which HEI's are more efficient and provides the degree of inefficiency present in each HEI's. For this application it is necessary to use statistical data to drive the DEA analysis.

To comparatively examine the performance of each university by taking advantage of all their resources using DEA, we apply an output-oriented efficiency measure since universities are increasingly confronted with the idea of output control in which the resources assigned to universities are directly related to the extent of services produced [46]. In the analysis below we examine two versions of the output-oriented DEA model. The first analysis will view efficiency measurement from the conventional input versus output perspective. This is presented in subsection 4.4.1. In subsection 4.4.2 we present an alternative model.

4.4.1 A conventional approach to efficiency modeling

For applying the output-oriented model, the following is the identified relationship among inputs and outputs:

Figure 22: Propose output-oriented model

For this study, the data used for American Universities were obtained from the book, *The Best 373 Colleges* [35], and the data obtained for ITESM was given by Eng. Nadia Loredo, who is responsible for the statistics at ENCSH, but Academic Rating and Financial Rating were obtained by the survey applied to students.

Table 22: Original data from American universities and ITESM

University	Academic rating (Ac)	Admissions rating (Ad)	Financial aid rating (F)	% graduated top 25 of class (T)	Job placement (J)	Students with internships (I)
	%	%	%	%	%	%
University of Notre Dame (Mendoza)	90.00	98.00	94.00	95.00	95.00	79.00
University of Virginia (McIntire)	93.00	98.00	94.00	97.00	78.00	86.30
Massachusetts Institute of Technology (Sloan)	97.00	99.00	96.00	100.00	94.00	90.90
University of Pennsylvania (Wharton)	91.00	99.00	95.00	100.00	90.00	85.20
Cornell University	92.00	98.00	96.00	98.00	93.00	85.30
University of California (Haas)	89.00	97.00	83.00	100.00	86.00	81.90
Emory University (Goizueta)	92.00	98.00	94.00	98.00	84.00	86.20
University of Michigan (Ross)	83.00	96.00	90.00	99.00	81.00	89.70
Boston College (Carroll)	89.00	97.00	94.00	95.00	83.00	84.10
University of Texas (McCombs)	74.00	94.00	90.00	95.00	100.00	84.20
New York University (Stern)	81.00	96.00	81.00	92.00	93.00	92.30
University of North Carolina (Kenan-Flagler)	83.00	97.00	92.00	96.00	97.00	77.30
University of Richmond (Robins)	94.00	94.00	94.00	87.00	100.00	77.70
Miami University (Farmer)	77.00	87.00	70.00	74.00	71.00	70.80
Babson College	85.00	93.00	90.00	87.00	64.00	85.10
Wake Forest University	89.00	95.00	89.00	91.00	93.00	78.80
Indiana University (Kelley)	76.00	87.00	77.00	71.00	90.00	73.80
Villanova University	88.00	95.00	70.00	88.00	82.00	89.00
Bentley University	80.00	90.00	85.00	79.00	90.00	86.20
Carnegie Mellon University (Tepper)	99.00	97.00	78.00	93.00	85.00	97.00
University of Southern California (Marshall)	85.00	98.00	95.00	97.00	62.00	82.50
College of William and Mary (Mason)	94.00	97.00	81.00	98.00	97.00	61.70
University of Illinois	72.00	88.00	78.00	89.00	72.00	74.90
University of San Diego	85.00	94.00	73.00	80.00	82.00	70.90
Pennsylvania State University (Smeal)	77.00	92.00	63.00	86.00	95.00	73.70
Southern Methodist University (Cox)	76.00	92.00	79.00	73.00	80.00	74.90
University of Washington (Foster)	75.00	94.00	76.00	13.00	55.00	63.60
Rensselaer Polytechnic Institute (Lally)	84.00	95.00	83.00	90.00	62.00	56.40
Boston University	72.00	95.00	64.00	91.00	76.00	82.10
Case Western Reserve University (Weatherhead)	81.00	92.00	93.00	87.00	90.00	73.50
Santa Clara University (Leavey)	83.00	89.00	70.00	76.00	82.00	68.80
DePaul University	75.00	82.00	67.00	29.00	66.00	62.90
James Madison University	75.00	88.00	72.00	72.00	70.00	61.40
University of Wisconsin	77.00	94.00	74.00	91.00	63.00	68.30
Michigan State University (Broad)	71.00	85.00	70.00	70.00	92.00	67.80
Texas A&M University (Mays)	71.00	87.00	85.00	89.00	74.00	58.10
Seattle University (Albers)	87.00	87.00	78.00	61.00	56.00	48.90
Syracuse University (Whitman)	80.00	92.00	89.00	73.00	68.00	87.00
Fordham University	84.00	92.00	75.00	73.00	80.00	87.60
University of Georgia (Terry)	72.00	93.00	75.00	89.00	75.00	53.20
Georgia Institute of Technology	72.00	95.00	77.00	95.00	78.00	61.20
ITESM (ENCSH)	84.25	93.00	76.71	35.00	69.48	47.10

The purpose of this research is to identify best practices with the help of DEA, by the identification of those universities that are located at the frontier (means which are efficient) against which ENCSH is competing in the education market. In this context, the data available only illustrate the quality of the university, but what is sought is that the institution under study adopts those practices which will allow it to be more attractive and competitive for consumers.

In this situation, it is helpful that all the data have the same unit of measure. In this case, because most of the variables are in percentages, the software could be applied without any constraints. Furthermore, since the scale of operations does not matter, because all of them are in the same units, we apply the CRS (Constant Returns to Scale) model, with the Out-put Oriented approach, because what we want to find is the extent to which outputs need to improve.

The following are the primal and dual forms of the DEA model

PRIMAL

$$Min\ v_1 Ac^o + v_2 Ad^o + v_3 F^o + v_4 T^o$$

Subject to

$$u_1 J^o + u_2 I^o = 1$$

$$v_1 Ac^j + v_2 Ad^j + v_3 F^j + v_4 T^j - u_1 J^j - u_2 I^j \geq 0$$

Assurance Region

For this study we have considered that the *% graduated top 25 of class* is the variable which generates a great impact in the rest of the inputs and in the same form the *Job Placement* is the variable affected by the *Students with Internship*. After analyzing the inequalities we can divide the assurance regions as follows:

Inputs:

$$\alpha_i \leq \frac{v_i}{v_{io}} \leq \beta_i$$

$$1 \leq \frac{Academic\ Rating}{\%\ graduated\ top\ 25\ of\ class} \leq 2 \quad = \quad 1 \leq \frac{v_1}{v_4} \leq 2$$

$$1 \leq \frac{Admission\ Rating}{\%\ graduated\ top\ 25\ of\ class} \leq 2 \quad = \quad 1 \leq \frac{v_2}{v_4} \leq 2$$

$$1 \leq \frac{Financial\ Rating}{\%\ graduated\ top\ 25\ of\ class} \leq 2 \quad = \quad 1 \leq \frac{v_3}{v_4} \leq 2$$

Outputs:

$$\delta_r \le \frac{\mu_r}{\mu_{ro}} \le \gamma_r,$$

$$1 \le \frac{Job\ Placement}{Students\ with\ Internship} \le 2 \quad = \quad 1 \le \frac{u_1}{u_2} \le 2$$

Then the restrictions will be transformed into constraints as it follows:

$$v_1 - v_4 \ge 0$$
$$-v_1 + 2v_4 \ge 0$$
$$v_2 - v_4 \ge 0$$
$$-v_2 + 2v_4 \ge 0$$
$$v_3 - v_4 \ge 0$$
$$-v_3 + 2v_4 \ge 0$$
$$u_1 - u_2 \ge 0$$
$$-u_1 + 2u_2 \ge 0$$

DUAL

$$Max\ \emptyset$$

subject to

$$\lambda_1 Ac^1 + \lambda_2 Ac^2 + \cdots + \lambda_{42} Ac^{42} + \delta_1 - \delta_2 \le Ac^o$$
$$\lambda_1 Ad^1 + \lambda_2 Ad^2 + \cdots + \lambda_{42} Ad^{42} + \delta_3 - \delta_4 \le Ad^o$$
$$\lambda_1 F^1 + \lambda_2 F^2 + \cdots + \lambda_{42} F^{42} + \delta_5 - \delta_6 \le F^o$$
$$\lambda_1 T^1 + \lambda_2 T^2 + \cdots + \lambda_{42} T^{42} - \delta_1 + 2\delta_2 - \delta_3 + 2\delta_4 - \delta_5 + 2\delta_6 \le T^o$$
$$-\lambda_1 J^1 - \lambda_2 J^2 - \cdots - \lambda_{42} J^{42} + \delta_7 - \delta_8 + \emptyset J^o \le 0$$
$$-\lambda_1 I^1 - \lambda_2 I^2 - \cdots - \lambda_{42} I^{42} - \delta_7 + 2\delta_8 + \emptyset I^o \le 0$$

After running the model using Excel with the aid of the Solver Tool, we have the following results shows in Table 23.

Table 23: Efficiency scores (%) for the current asset model

Universities	Output-oriented CRS efficiencies	Benchmarking				
		Lambda	University	Lambda	University
University of Notre Dame (Mendoza)	1.144975413	1.246719	Michigan State University (Broad)		
University of Virginia (McIntire)	1.22533679	1.259843	Michigan State University (Broad)		
Massachusetts Institute of Technology (Sloan)	1.113772217	1.288714	Michigan State University (Broad)		
University of Pennsylvania (Wharton)	1.716222685	1.267742	Michigan State University (Broad)		
Cornell University	1.133828827	1.265092	Michigan State University (Broad)		
University of California (Haas)	1.159965753	0.212263	Pennsylvania State University (Smeal)	0.994677	Michigan State University (Broad)
Emory University (Goizueta)	1.182860368	1.259843	Michigan State University (Broad)		
University of Michigan (Ross)	1.132914047	0.372848	University of Texas (McCombs)	0.780412	Michigan State University (Broad)
Boston College (Carroll)	1.184724441	1.238845	Michigan State University (Broad)		
University of Texas (McCombs)	1	3.05E-10	Michigan State University (Broad)		
New York University (Stern)	1.004551877	0.049519	Pennsylvania State University (Smeal)	1.112576	Michigan State University (Broad)
University of North Carolina (Kenan-Flagler)	1.111543792	0.392887	University of Texas (McCombs)	0.759526	Michigan State University (Broad)
University of Richmond (Robins)	1.092811767	1.215223	Michigan State University (Broad)		
Miami University (Farmer)	1.163547659	0.208644	Pennsylvania State University (Smeal)	0.812221	Michigan State University (Broad)
Babson College	1.260236837	1.175853	Michigan State University (Broad)		
Wake Forest University	1.120576022	1.204724	Michigan State University (Broad)		
Indiana University (Kelley)	1.019109791	1.044619	Michigan State University (Broad)		
Villanova University	1.053762822	0.819672	Pennsylvania State University (Smeal)	0.262295	Michigan State University (Broad)
Bentley University	1.009280196	1.112861	Michigan State University (Broad)		
Carnegie Mellon University (Tepper)	1.058753658	0.588035	Pennsylvania State University (Smeal)	0.585054	Michigan State University (Broad)
University of Southern California (Marshall)	1.365239905	0.338132	University of Texas (McCombs)	0.844764	Michigan State University (Broad)
College of William and Mary (Mason)	1.196544939	1.215078	Michigan State University (Broad)		
University of Illinois	1.172059135	0.27696	University of Texas (McCombs)	0.758195	Michigan State University (Broad)
University of San Diego	1.15944831	0.427294	Pennsylvania State University (Smeal)	0.658293	Michigan State University (Broad)
Pennsylvania State University (Smeal)	1	4.9E-10	Michigan State University (Broad)		
Southern Methodist University (Cox)	1.11315202	1.079019	Michigan State University (Broad)		
University of Washington (Foster)	1.17441092	0.871622	Michigan State University (Broad)		
Rensselaer Polytechnic Institute (Lally)	1.916704553	1.232019	University of Texas (McCombs)		
Boston University	1.066301098	0.903511	Pennsylvania State University (Smeal)	0.101126	Michigan State University (Broad)
Case Western Reserve University (Weatherhead)	1.137389227	0.207169	University of Texas (McCombs)	0.924922	Michigan State University (Broad)
Santa Clara University (Leavey)	1.123610985	0.387481	Pennsylvania State University (Smeal)	0.651267	Michigan State University (Broad)
DePaul University	1.059626151	0.85473	Michigan State University (Broad)		
James Madison University	1.259668644	0.046413	Pennsylvania State University (Smeal)	0.9868	Michigan State University (Broad)
University of Wisconsin	1.355530226	0.363734	Pennsylvania State University (Smeal)	0.729783	Michigan State University (Broad)
Michigan State University (Broad)	1				
Texas A&M University (Mays)	1.311408581	0.445097	University of Texas (McCombs)	0.571027	Michigan State University (Broad)
Seattle University (Albers)	1.59932344	1.049869	Michigan State University (Broad)		
Syracuse University (Whitman)	1.17238717	0.09427	University of Texas (McCombs)	1.028507	Michigan State University (Broad)
Fordham University	1.038789676	0.116032	Pennsylvania State University (Smeal)	0.967	Michigan State University (Broad)
University of Georgia (Terry)	1.349763059	1.089245	Michigan State University (Broad)		
Georgia Institute of Technology	1.282399246	0.109726	Pennsylvania State University (Smeal)	1.001247	Michigan State University (Broad)
ITESM	1.32799159	0.976216	Michigan State University (Broad)		

Here the DMUs (universities) that have an output-oriented CRS efficiency score of 1, are the frontier (efficient) units. Those with scores higher than one are the inefficient units. The score for ENCSH at ITESM is 1.32, meaning that the target

for that school is to increase its outputs, internships and jobs, by 32%. Furthermore, Table 23 gives the value of lambda of 97.62%. This means that if and when ENCSH at ITESM reaches its target internships and jobs on the frontier, the resulting "virtual" university can be thought of as a scaled-down version of Michigan State University (Broad College of Business). The complexity of the dual formulation of the models given above is such as that it is difficult to give a precise description of the projected point in terms of lambda only. The other dual variables namely the deltas play a role in this projection as well. It is only when one takes into account all of these variables that we get a true picture of the projected point.

For a better understanding, the following illustrates what we have previously stated.
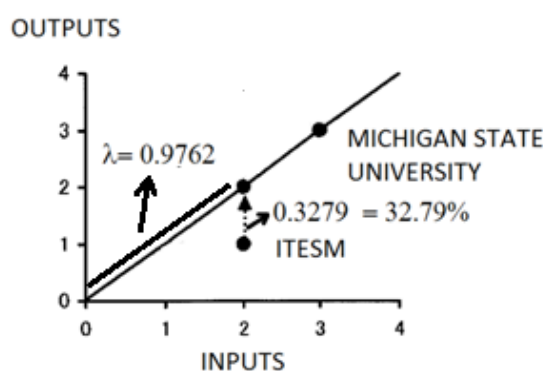
Figure 23: Results for ENCSH

4.4.2 An alternative approach to efficiency: Dual role factors

The previous sections presented a conventional output-oriented DEA model for evaluating the relative efficiency of the set of universities in the data set under study. The view then was that the inputs were various ratings (Academic, admission, financial and percentage of students in top 25% their classes), and outputs were the percentage of students earning students internships and obtaining jobs following graduation.

In this section a somewhat different view is taken in regard to the process involved relating to the progression of the student from entry to exit. The figure below captures the perceived time line followed by the students. Specifically, the stature of the institution is reflected through its various ratings as described above, and these are believed to aid students in earning internships and jobs. The latter do play an important role as outputs, but do occur at different point in time. Internship are served, while the student is still enrolled while jobs are generally

obtained following graduation. Furthermore, internships are believed to play a significant part in the students' success in the job market.
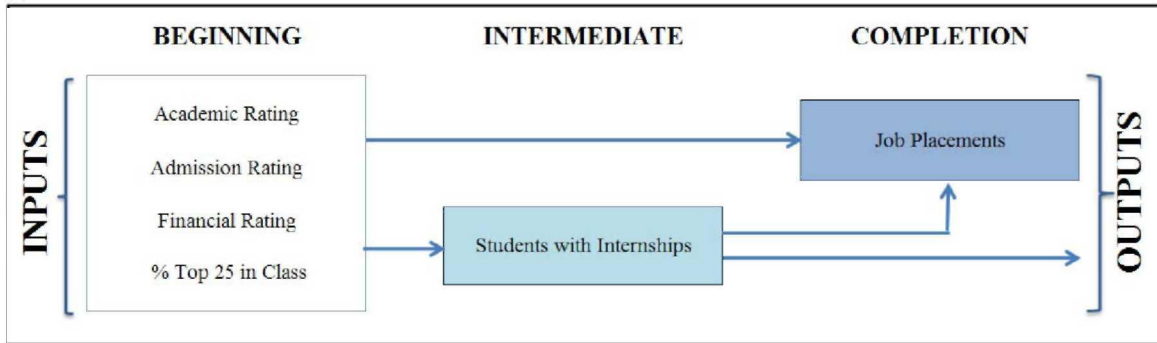
Figure 24: An alternative approach to efficiency

Hence, as denoted in the figure, internships are an intermediate output; while at the same time play an additional role as an input to job success.

The concept of a "dual role" factor (internships) is not a new phenomenon in DEA modeling. This phrase as first used by Cook, Green and Zhu (2006) in investigating the role played by research funds in evaluating a set of British universities. Their paper was responding and earlier article by Beasley where he included the research variable in both the numerator and denominator of the efficiency ratio specifically, Beasley's model (input oriented) was:

$$e_o = \max \frac{[\sum_r u_r y_{ro} + gR_o]}{[\sum_i v_i x_{io} + bR_o]}$$

subject to

$$\frac{[\sum_r u_r y_{rj} + gR_j]}{[\sum_i v_i x_{ij} + bR_j]} \leq 1 \quad , \forall j$$

$$u_r, v_i, g, b \geq 0$$

The problem with this model is that if one were to transform this to a linear programming problem the dual of this problem world call for the radial (proportional) reduction of all inputs, including R_o on the input side as a nondiscretionary variable. Recall that a nondiscretionary variable is one on which management has no control. The standard way of treating non discretionary inputs in a modeling sense is to represent them as undesirable outputs. That being, the case the modified version of Beasley's model then becomes:

$$e_o = \max \frac{[\sum_r u_r y_{ro} + gR_o - bR_o]}{\sum_i v_i x_{io}}$$

subject to

$$\frac{[\sum_r u_r y_{rj} + gR_j - bR_j]}{\sum_i v_i x_{ij}} \leq 1 \quad , \quad \forall j$$

$$u_r, v_i, g, b \geq 0$$

Cook et al. (2006) demonstrate that at the optimum of this problem, either g o b will be equal to 0 (cero). In other words, the DMU (university) is at liberty to set these multipliers at whatever values make its efficiency score the most fair or able. It will therefore choose to make $b = 0$, when R_o is small relative to other universities.

In the present setting, it is argued that internships I_j play a dual role and therefore their proper treatment is important in capturing the efficiency standing of a university. The approach taken here is related to the Cook et al. (2006) with two notable exceptions. First, we view internships as discretionary, in stand contrast to the treatment of research expenses, namely as non discretionary. Second, as pointed out in the earlier section, it is important to impose appropriate multiplier restrictions (assurance region constraints).

Recalling that it is the output-oriented model that best capture efficiency in the present setting, we propose the following model to replicate the process shown in the figure. We first examine the problem in the absence of assurance region constraints.

$$\hat{e}_o = \min \frac{\sum_i v_i x_{io}}{[\sum_r u_r y_{ro} + gI_o - bI_o]}$$

subject to

$$\frac{\sum_i v_i x_{ij}}{[\sum_r u_r y_{rj} + gI_j - bI_j]} \geq 1$$

$$u_r, v_i, g, b \geq 0$$

Applying the usual transformation of variables, this ratio model is equivalent to the linear programming problem:

$$\hat{e}_o = \min \sum_i v_i x_{io}$$

subject to

$$\sum_r u_r y_{ro} + \gamma I_o - \beta I_o = 1$$

$$\sum_i v_i x_{ij} - \sum_r u_r y_{rj} - \gamma I_j + \beta I_j \geq 0, \quad \forall j$$

$$u_r, v_i, \gamma, \beta \geq 0$$

It is useful to note that the dual of this problem is:

$$\widehat{\emptyset}_o = \max \emptyset$$

Subject to

$$\sum_{j=1}^n \lambda_j \, x_{ij} \leq x_{io}$$

$$\sum_{j=1}^n \lambda_j J_j \geq \emptyset J_o$$

$$\sum_{j=1}^n \lambda_j \, I_j \geq \emptyset I_o \; [Internships \; treated \; as \; outputs]$$

$$\sum_{j=1}^n \lambda_j \, I_j \leq \emptyset I_o \; [Internships \; treated \; as \; inputs]$$

$$\lambda_j \geq 0, \qquad \emptyset \; unrestricted \; in \; sign$$

It should be pointed out that the expression $\gamma I_o - \beta I_o$ (where $\gamma, \beta \geq 0$) can be replaced by $(\gamma - \beta) I_o = \delta I_o$ where the variable δ is unrestricted in sign. A positive value of δ implies that the DMU is treating internships as an output, while $\delta < 0$ signals treatment as input, since the model gives a university the liberty to choose the multipliers that favorable light, this will mean that if I_o is low in value relative to internships competing schools, DMU_o will prefer to declare I_o as an input ($\gamma = 0, \beta > 0, ie \; \delta < 0$). Conversily, when I_o is large relative to other I_j, it is in that university host interest to treat that variable as an output. ($\gamma > 0, \beta = 0, ie \; \delta > 0$)

4.4.2.1 Dual role variables and assurance region

In the above formulation of the primal model, multiplier restrictions of the type discussed earlier have been ignored. If we wish to reintroduce assurance region involving internships, we now have to consider what this will mean given the two roles Internships plays. Viewing Internships as an output, it is pertinent to impose the restriction:

$$a \leq \frac{u}{\gamma} \leq b,$$

Where if we follow the earlier argument, we might set $a = 1, b = 2$. Viewing Internships as an input, it appears to be appropriate to impose a restriction connecting the multiplier β to the other input (with multipliers v_1, v_2, v_3, v_4). Taking v_4 as a numeraire, and following the logic earlier we suggest imposing the constraint:

$$1 \leq \frac{\beta}{v_4} \leq 2$$

Note that this can also be expressed as:

$$\frac{1}{2} \leq \frac{v_4}{\beta} \leq 1$$

As described above, in the absence of such multiplier restriction, it is the case that as the optimum either $\gamma\beta = 0$ will always hold. Alternatively, we may view Inputs (I) as having the unrestricted in sign variable δ as its multiplier. What is required is Assurance Region constraint on δ, whereby the output variable constraints invoked when $\delta > 0$ and the input variable constraints are imposed when $\delta < 0$. The problem is that one doesn't know what sing δ will assume and moreover its sing is influenced by these AR constraints.

The solution to this problem appears to be to create a mechanism for invoking one set of constraints or the other (but not both), with that goal in mind, define the binary variable δ and replace the above two sets of contraints by the sets:

$$\gamma \leq \mu \leq 2\gamma + M(1 - d)$$

$$\gamma \leq Md$$

$$\frac{1}{2}\beta \leq v_4 \leq \beta + Md$$

$$\beta \leq M(1 - d)$$

where M is a large number.

Note that if $d = 1$ the output constraints (involving γ) are imposed and β is set to 0 (cero). If $d = 0$, the opposite is there namely γ goes to 0 (cero), and the input constraint on β are implemented.

4.5 Identifying best practices

Before starting with the best practices from Eli Broad College of Business at Michigan State University, it is interesting to get a general view of this college.

4.5.1 Eli Broad College of Business

"The Broad College of Business is one of the largest undergraduate business programs in the world with an enrollment of over 5,000 students. U.S. News & World Report 2012 rankings place the Broad College 14th among public institutions and 24th nationally, which places the College among the top undergraduate business programs in the United States" [47]. The enrollment in the Broad College of Business is limited, and admission to the College is competitive. Admission decisions are based on a hybrid model which considers academic and non-academic factors [47]. In the web page of Bloomberg Businessweek [48], there is statistical information from the 2010-2011 school year:

4.5.1.1.1 Enrolment [48]

Table 24: Enrolment at Eli Broad College of Business

Information	Count
Institution's total undergraduate enrollment	47,131
Undergraduate business program's full-time enrollment	1,924
Undergraduate business program's part-time enrollment	224
Undergraduate business program's distance enrollment	0

4.5.1.1.2 Admissions - getting into the business program [48]

Table 25: Admissions in the business program

Information	Count/Percentage
Total number of applicants (admitted and denied) to the undergraduate business program (2010-11 academic year)	1466
Percentage of applicants admitted to the program (selectivity)	69%
Percentage of admitted applicants who enrolled (yield)	99%

4.5.1.1.3 Academic [48]

4.5.1.1.3.1 Percentage of business classes:[48]

Table 26: Percentage of business classes

Information	Percentage
With 20 or fewer students	13%
With 21 to 50 students	74%
With more than 50 students	13%

4.5.1.1.3.2 Course enrollment: [48]

Table 27: Course enrolment at Broad College of Business

Information	Count/Percentage
Percentage of required business courses reaching maximum enrollment by the first day of class	90%
Percentage of required business courses with waiting lists	17%
Total number of faculty currently teaching in the undergraduate business program	85

4.5.1.1.4   Job opportunities

4.5.1.1.4.1 Job offers:[48]

Table 28: Job offers for students from Broad College of Business

Information	Percentage
Received first job offer by graduation	85%
Received first job offer after graduation, but within 3 months	11%
Received first job offer more than 3 months after graduation	4%
Did not report having received a job offer	0%
Accepted first job offer by graduation	85%
Accepted first job offer after graduation, but within 3 months	10%
Accepted first job offer more than 3 months after graduation	5%
Did not report having accepted a job offer	0%

4.5.1.1.4.2 Percentage of 2009-10 academic year graduates who accepted jobs in the following functional areas: :[48]

Table 29: Percentage of graduate students who accepted job in different functional areas

Major	Percentage
Consulting	4%
Finance/Accounting	16%
General Management	42%
Human Resources	2%
Management Information Systems	0%
Marketing/Sales	10%
Operations/Production	10%
Logistics/Transportation	7%
Other	9%

4.5.2 Best practices

The following step is obtaining those best practices from Eli Broad College of Business, which could be adopted by ENCSH for become more attractive for students.

In a Debate at Linked In, started by the author of this research, was proposed that professors, alumni or college staff be able to express what they think there are the best practices to attract students. One of the followers, a student at Michigan State University express their thoughts at:

And she stated the following

"I have several thoughts -- some from memories of making my own college choice decades ago, and some that are more "business oriented" –

1. Great faculty: these folks need to have the "right credentials" AND they need to be accessible to students. Going to a huge university intimidates many students, and classrooms that hold 600 students add to that, but it can be overcome by having accessibility - whether it's a professor that hangs around a few minutes after class, or office hours.
2. Great programs with sufficient availability of classes.
3. Great students - a major deciding factor in my choice, all those years ago, was the difference I perceived in the student body at MSU. I was invited to compete for the Alumni Distinguished Scholarship, which at the time, involved visiting campus for a weekend, and staying in the dorm with some of the most welcoming people I had met. I remember walking around campus, wandering with my map, and being asked if I needed help or directions. I felt welcome, and NOT ALONE amongst the 40000+ people on that campus. Let's just say that was not how I felt on some other campuses.
4. Make campus accessible to prospective students and make current students available to prospective students. Someone from the Student Alumni association calls me several times a year, to see if I will make a pledge... Might it not be better to have those people call prospective students to talk to them about what's going on, on MSU's campus, and making them feel welcome?"

Looking the previous answer, it is easy to realize how important the following features are:

1) Accessibility and support from Faculty and Staff member, who can help students to solve questions and small problems.
2) Have important Education Programs, in terms that could impact student's future and create on them a competitive advantage.
3) Students focus on those universities where they could increase their reputation, in terms that they want to be enrolled in the universities where only the best of the students could study, further they want to be awarded with scholarship because of their great development in their studies.
4) Finally, they want to find a great environment of welcome for everybody, for new and current alumni members.

Analyzing the previous best practices, it is necessary to enlarge the list already exposed by a student from MSU. Thus, a benchmarking could help to accomplish the goal.

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Although ENCSH has many important features which should be considered attractive for students, there are some "special" characteristics which make it possible for this school gaining a better competitive advantage among its peers. The results obtained from the DEA Analysis and the benchmarking of ENCSH at ITESM against Eli Broad College of Business at Michigan State University, produces an important opportunity to learn, because all the best practices will help to improve the University under study, in terms such as modernize its management, promote its attractiveness and create a learning environmentto increase institutional performance. Thus, ENCSH will be able to grow its competitiveness which provides features and other opportunities to be considered among many alternatives and also enables the identification of processes needing improvement.

In the case of ENCSH, the best practices which should be included are those identified by going through Eli Broad College of Business web page. They include some structural and organizational changes associated with diversification and increasing their marketing of higher education systems, establishment of new institutions and courses of study, opening up ways that help students for their future labor market requirements, with increasing professionalization and rising qualification requirements for many employment opportunities [49].

The following list could be added to the previous already mentioned by the experienced of a student explained at the social networking Linked In.

4.5.3 List of best practices

4.5.3.1 Rankings

Worldwide, students consider an important issue the University Rankings, in order to enroll in it. They believe that rankings give them a guidance to help them to make the right choice and get a wide perspective of the benefits of being involved in a Higher Education Institution.

Looking through the Web Page of the Broad College of Business and some Annual Reports, students have the opportunity to visualize the position in the World University Rankings of their university and their schools, in different indicators. However, analysis shows that students focus on reputation of their programs and the impact in the labor market. The case of Broad College gives a clear example of this explanation.

Financial Times ranks Broad 1st in U.S. in placement success

Financial Times recently released its 2012 annual ranking, ranking the Broad College at 1st in the U.S. and 2nd out of all business schools in the world in

"placement success." Broad has been among the top four in this category nearly every year since 2001. Although they celebrate their achievements, they also continue their work to create quality student learning experiences that focus on value creation in the global marketplace, which is so important in business today" [50].

Furthermore the undergraduate International Business Program has also been recognized as one of the top 25 programs nationally, having been ranked 24th by *U.S. News and World Report,* while the undergraduate business program in its entirety climbed from 28th in the 2010 rankings to 24th in 2011 and to 14th among public institutions [51].

4.5.3.2 Support alumni association by business seminars and workshops

As described earlier, students want to be enrolled in those universities which help them to be familiar with their future and create competitive advantages which overcome their peers. An example of this situation is the wide networking gained by the students at Broad College of Business in their university years. Broad College through their web pages has posted the way they help their students, and it is stated as follows:

Every student knows that networking is an important key to success; they have in mind that the more people they know the better. In this context, they have tried to increase their network while advancing in their careers, thus they will be able to build their business, increase their impact on the world and improve their social lives. "Broad College alumni consider career networking important and typically show willingness to attend business seminars and workshops" [52]. Thus, from Chicago to China, Michigan State University Alumni Association (MSUAA) alumni clubs, help make an unfamiliar place seem familiar and can connect people back to their alma mater. Since 2006, Broad alumni have formed Business Alumni Networks to facilitate business-focused networking opportunities, such as forums, dean and faculty receptions, and alumni breakfast meetings to help their students increase their learning and experience [52].

Other ways that Broad College of Business contributes to students is to increment their networking is by the Annual Business Event.

4.5.3.3 Annual MSU business event

"Since 1995 the MSU sponsors a major networking event for alumni, students and local business leader. Every year, new CEO, or Managers from different

companies are invited to participate in this event in order to increase the networking" [53]. This event increases the interest of the students because they can visualize how Broad College is helping them to be introduced to the Labor Market in an easy way.

4.5.3.4 Extensive social networking

Students are able to get the most updated information about the University through their social networking. It is well known that social networking constitutes a good way to make connections with people with similar interests and goals, and in the case for universities, people have the opportunity to meet other students, staff, faculty and even alumni.

Social networking sites offer campus surveys, such as the case of Broad College of Business, which always connects with their students through their accounts at Twitter at @EliBroadMSU to answer questionnaires. Examples such as the Businessweek survey help the University to be ranked, list events and other information that communicates campus culture. Therefore, they can be a great way to understand and stay connected to your campus community as a whole.

Thus, Broad College of Business has improved their search features and has greatly enhanced their social networking capabilities of the site, allowing users to connect with them via Facebook, Twitter, LinkedIn, and multiple RSS feeds [51].

Figure 25: Eli Broad College of Business Facebook social networking
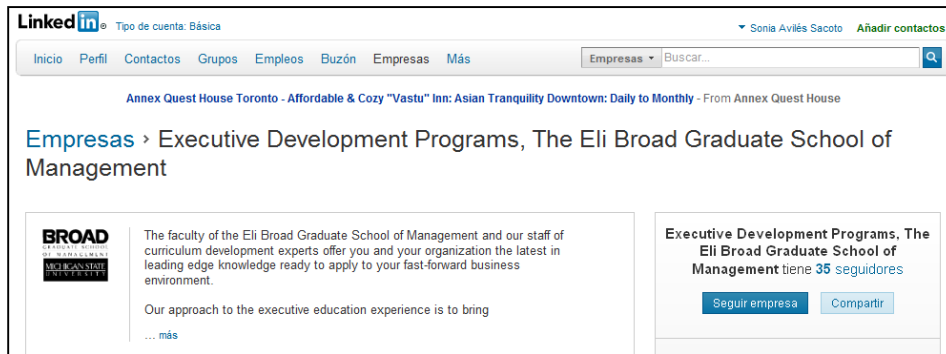
Figure 26: Eli Broad College of Business Linked In social networking

Figure 27: Eli Broad College of Business Twitter social networking

4.5.3.5 Awards in students lifetime

In order to enhance their qualities and skills and further increase the loyalty from their students, Broad College of Business has created special criteria to make awards students and ex-students for their efforts.

4.5.3.5.1 Current Students

Motivation is an important element in people's lives. Thus, Broad College grants award to those students in order to enhance their development in their studies. The awards recognize those students who have shown extraordinary leadership throughout their professional careers and who have distinguished themselves by achieving a consistently high level of excellence in their endeavors. Their achievements should be reflected in their community reputation and the recognition they have received from their peers because of their leadership for a long period of time [54].

"Furthermore, there is an award from Broad College of Business called Young Alumni Achievement Award, created to honor alumni who graduated in the past ten years and have shown a strong record of accomplishments – outstanding contributions to their employer, history of quick promotion, military accomplishments, service to the college, continued education and other noteworthy achievements. This serves to narrow the gap between professional and college, and strengthens faith and allegiance to the University, thanks to continuous monitoring of their customers, directly impacting the reputation of the university" [54].

4.5.3.6 Opportunities at MSU for increasing visibility [55]

MSU in all its faculties has a continuous interest in innovative ways to enhance their students' requirement efforts. Beyond traditional recruiting activities such as job postings and career fairs, MSU offers a wide variety of other opportunities to personalize student's strategy and enhance their organization's visibility on campus. Personal recruitment strategies include:

a. Broad Freshman Program
b. Project Green
c. Assist with practice interviews
d. Serving as a job shadowing site
e. Conduct special topic presentations
f. Company information tables
g. Give customized presentations to student organizations
h. Sponsor an invitation only event
i. Participate in leadership training
j. Career services network spring break corporate tour
k. Participate in the Freshman Seminar
l. Conduct class presentations
m. Connect with business faculty
n. Offer internships

4.5.3.7 Demmer center for business transformation established at MSU

Students are able to start a work perspective through consultancy support to professors working on projects in Michigan manufacturing business is what has developed the Broad College of Business since they started their Demmer Center for Business Transformation.

Michigan businesses will gain enhanced access to Broad College of Business expertise

The Michigan State University Broad College of Business, through the John and Marnie Demmer Center for Business Transformation, was established to aid Michigan manufacturing businesses in becoming domestically and globally competitive. This new center provides consulting, advisory, and educational services by faculty members and student teams to help Michigan-based companies strengthen their competitive performance [56]. "These activities will allow Michigan business leaders to access research on business process transformation with an emphasis on growth strategies, lean manufacturing and supply chain, and quality processes and metrics. Additionally, this center will provide funding for faculty members and students to work with companies and for educational grants to smaller companies to enable them to participate in executive education programs that will be offered by the center" [56]. The Demmer Center, housed within the Broad College's Institute for Entrepreneurship and Innovation, will draw upon the experience of the Demmer Corporation, as well as the research of Broad College faculty and the talents of their students [56].

4.5.3.8 Different and new majors

The majors offered by Broad College of Business focus in the following fields:

a. Accounting (ACC): Prepares students for careers in public accounting, managerial accounting, and governmental accounting. The public accountant is involved in auditing, in planning, and in providing specialized advice on business problems. The managerial accountant is responsible for generating the information needed to plan and control a company's operations. Local, state, and federal government agencies offer opportunities in governmental accounting [57].

b. Finance (FI): Comprises corporate financial management, management of financial institutions, and investments. An understanding of financial concepts, financial instruments and financial management decision–making are vital to each. Employment opportunities exist in industrial and brokerage firms, public utilities, banks, insurance companies, credits unions, and agencies of government [57].

c. General Management (GM): Students are introduced to a wide range of business fields. Students select courses from accounting, finance, management, marketing, economics, and law. The program prepares students for the numerous, diverse entry-level opportunities in the business world [57].

d. Hospitality Business (HB): The leader in hospitality business education, The School is an independent school within the Broad College of Business. Students earn a highly versatile hospitality business bachelor of arts degree with a rigorous and relevant curriculum. The curriculum draws from three areas of study: General Education, Business and Hospitality [57].

e. Human Resource Management (HRM): This field of concentration focuses on personnel management in organizations, on the role and development of the manager as a leader and on the specific functions and mission of the personnel/human resources department. Entry-level positions are obtained in private and public enterprise and wherever the personnel function is departmentalized [57].

f. Marketing (MKT): Study in this field stresses understanding of marketing concepts and tools, application of the concepts and tools to achieve objectives using analysis, planning, implementation, and control techniques, and integration of marketing with other business functions and societal processes. Career opportunities are available in marketing management, market research, industrial sales, retail and sales management and other areas [57].

g. Supply Chain Management (SCM): Supply Chain Management integrates topics from manufacturing operations, purchasing, transportation, and physical distribution into a unified program. The program offers integration among these critical, value-adding components to enhance global competitiveness. The objectives are to provide students with a comprehensive background in each area and also to allow students to pursue concentrations within their areas of interest [57].

After analyzing all the majors, it sounds interesting the Major of Hospitality Business (HB) not offered in all the universities. Some features and characteristics about this major are following detailed:

Hospitality Business

Students earn a highly versatile hospitality business bachelor of arts .The business degree offered by *The* School is attractive to employers and graduate schools alike. The hospitality classes offer a perfect mix of theory and practical application, with feature hands-on experiences and group dynamics, emphasize teamwork and problem solving, it involves real-world situations with frequently visits from leaders from the industry for a real-world perspective on the subject.

In addition students have the opportunity to get two paid internships, which are required as a part of the undergraduate program experience [47].

Why does The School of Hospitality Business require the completion of two internships? [58]

- After graduation students will assume a management role in the hospitality industry; thus, they must be able to direct and lead employees working in hourly and supervisory positions in a hospitality company. Having work experience will allow them to learn what these jobs entail and what skills are need to perform them. They will also learn about the day-to-day operations of a hospitality

company, how it is organized and managed, daily work issues, and financial considerations [58].

- "Employers will seek to hire students with significant work experience to become managers for their companies. Internships will strengthen their skill set and help them to develop their problem solving and leadership skills (what recruiters are looking for) So the more experience students have the stronger a candidates they will be"[58].
- "With so many choices of jobs in the hospitality industry, internships will also help them decide what segment of the industry is right for them" [58].
- Students could apply what they have learned in classrooms in a real world setting. Both are needed to be a successful manager in the hospitality industry [58].
- "Internships will also provide them with powerful networking connections for a future job with the company of their dreams, for future advancement, or for mentoring" [58].

Both internships have to be done prior to graduation and they must be in the hospitality industry. It is required a minimum of 400 hours each one during a 10 week period with one company. Internships can be completed full time during the summer or part time during the school year. If you work part time there is no time limit for completing 400 hours, then they must be documented and employer must also complete evaluations through web evaluation process [58].

4.5.3.9 Specializations and minors

Broad students have the opportunity to enroll in any academic minor or specialization at MSU for which they want to increase their knowledge and learning. The following specializations and minors can be combined with majors in Accounting, Finance, General Management, Human Resource Management, Marketing, or Supply Chain Management.

a. Entrepreneurship Specialization: Gain knowledge upon entrepreneurially-focused research in the core business disciplines, including accounting, business law, finance, management, and marketing [59].
b. Environmental Studies Specialization: Gain skills and knowledge in the environmental sciences necessary for any graduate considering careers that may involve the "greening" of the economy [59].
c. Information Technology (IT) Specialization: Prepares students for careers in systems consulting, business analysis and tech support [59].
d. International Business (IB) Minor: Attractive to students who plan careers with an international orientation. Add an international breadth to their major. Increase their understanding of various regions of the world and prepare for a global marketplace [59].

e. <u>Sales Communication Specialization</u>: Provides students with educational experiences, courses, and training they need to become successful sales agents and leaders in a sales-intensive corporate setting [59].

f. <u>Sustainability Specialization</u>: Students gain holistic and integrated competencies around aesthetic appreciation, ecological integrity, social equity, and economic vitality [59].

4.5.3.10 Broad enrichment opportunities

4.5.3.10.1 Broad Scholar Program (BSP)

It is an undergraduate student mentor program initiated in the fall of 1995 to provide more opportunities for first year business students to work closely with faculty members in The Eli Broad College of Business [60].

This employment opportunity is similar to the Honors College Professorial Assistantship Program by offering a monthly stipend and experience working with a faculty member in their college of interest [60].

Broad Scholars are expected to work an average of 10 hours a week during fall and spring semesters. They participate in a variety of scholarly activities; assisting in publishing articles, data collection and research. They are reappointed for a second year, pending satisfactory performance as determined by the faculty mentor and the program coordinator. Meetings, presentations and social opportunities will be available throughout the year [60].

4.5.3.11 Journal of International Business Studies

"The *Journal of International Business Studies* is the official publication of the *Academy of International Business*, which is housed in the Eli Broad School. The permanent Editorial Office for JIBS is housed in the Broad School. It is the leading peer-reviewed, scholarly journal focusing on research that spans the entirety of international business studies. The journal publishes papers of significant interest that contribute to the theoretical basis of business and management studies. The Journal of International Business Studies' broad scope and developmental editorial policies create accessible, thought-provoking content for the general academic business community" [61].

In the latest Journal Citation reports, JIBS had an Impact Factor of 2.992, which means JIBS is now listed at number eight in the business category and also at number seven in the management category [61].

Having their own journal generates an impact in the students because they are more attracted to work in research and papers, which could be considered to publish. Thus, for students are motivated to do research and write papers, which contributes that students consider not only to have their career programs there, but also become scholars and decided to study their Master's and Doctorate Programs in the same Business College.

CHAPTER 5: CONCLUSIONS

5.1 The Issues

This thesis sets out to examine the problem face by many higher education institutions in retaining and/or increasing undergraduate student enrolments. The thesis focuses explicitly on a case study of the Mexican university ITESM, and in particular Business school– ENCSH from the Spanish "Escuela de Negocios, Ciencias Sociales y Humanidades".

Four questions capture the sequence of issues addressed in the thesis:

Question 1: What are the main characteristics or factors considered important by students when selecting a college?

Question 2: Given these factors, How should students identify those universities that are most attractive, where does ITESM stand relative to those best alternatives (leading schools), and what targets for improvement should ITESM set to come to the level of those best schools?

Question 3: What are the main differences among the best schools under study versus ITESM?

Question 4: What are the best practices of the leading schools against which ITESM is benchmarked?

5.2 The results

Question 1:

To address this question a literature review on HEIs was undertaken. At the same time, data was collected on a large sample of US schools and a survey was done involving ITESM students. The latter was close to gain an understanding of student's view on key factors attracting them to particular schools. The literature review identified international internships and job prospects following graduation as the primary factor motivating students' interests in attending on HEI.

In the survey undertaken at the outset of the thesis, students largely expressed that a choice of school to attend depended heavily on the service provided together with what they (the students) perceived as measures of quality. The principal descriptors of service and quality were:

1. Academic Rating – this includes program prestige, teaching quality, and accessibility of professors;

2. Admission Rating – captures competitiveness of the school;
3. Financial Rating - a measure of how satisfied students are with financial aid received;
4. Top 25% of class –this is the percentage of freshmen who ranked in the top quartile in the high school classes.

Question 2:

This question was addressed using the well established efficiency measurement tool, Data Envelopment Analysis (DEA). This tool allows one to evaluate the efficiency of each university in the sample relative to all other universities in the group. The conventional approach in DEA is to define a set of inputs used (often the resources on the environment in which the organization operates) and a set of output believed to be influenced by the inputs. We argue therein that the four service/quality descriptors described above are reasonable input factors. We take internships and jobs as the "results" or outcomes/outputs, reflecting benefits received by the students.

While the conventional DEA model could be applied here, two important considerations where mate that resulted in alterations to the DEA structure. First, it is important to impose appropriate restrictions on the DEA multiplier. For this, the well known assurance region (AR) methodology was invoked. AR restrictions insure that undesirable or inappropriate multiplier profiles are avoided. Second, unlike the usual situation where factors are clearly divided into separate sets (inputs and outputs), here the two outputs behave somewhat differently than generally the case. Specifically, internships occur during the time that the student is enrolled in the university, while jobs normally occur after graduation, and can be influenced by internships. This results in internships assuming a form of dual role (both an input and output). A modified revision of the conventional DEA structure was developed herein.

In applying DEA to ITESM, is generated an efficiency score of 1.32%, meaning that in the case of ITESM, its turns output would need to improve (increase) by 32% to bring it to an "efficient" status. The efficient university against which it is compared is the Eli Broad College of Business at Michigan State University (MSU).

Question 3:

After the benchmarking analysis between ENCSH at ITESM and the Eli Broad College of Business, it is evident that the latter has some practices and features which are more attractive for students. Those features constitute a competitive strategies focused creating a successful future for students.

Looking through Eli Broad College of Business, and after a debate in the Social Networking Linked In, we can begin to identify those features and best practices developed by the Broad College of Business, and it gives the opportunity to

ENCSH to consider some of them which could contribute to improve their performance and create a competitive advantage to attract students.

Question 4:

Best practices considered by alumnus

1. The university should create a commitment of accessibility and support in their Faculty and Staff Members
2. The Educational Programs offered by the Institution have to create a competitive advantage for student's future lives
3. Improve not only the reputation of their programs but also the university as a whole. Further try to rise the opportunities of financial support to those students who contributes to the Educational reputation of the university.
4. The university has to provide an environment of welcome and friendly for their ex-alumni, current and prospective students.

Best practices carried by Eli Broad College of Business

1. Focus in the continuous improvement through the gaining of a better position in the World University Rankings.
2. Support to their students through fairs, seminars and events, in which students could develop a wide networking with entrepreneurs, professors and other students.
3. Dispose a great Social Networking in which students could get the most update information from their University.
4. Awards and prizes for their student community (Ex-alumni and current students).
5. Dispose a Center to support local organizations and create the opportunity to students to develop skills of consulting and start their enrollment through the labor market.
6. Offer different and innovative Educational Programs, with different approach and minors where students could deepen their knowledge and learning.
7. Have their own Journal, thus students are able to increase their search skills and publish their works.

5.3 Conclusions of the research

The DEA methodology is a powerful tool for measuring efficiency in organizations. It provides a means of establishing benchmarks, or top performers against which inefficient organization can be compared. These benchmarks provide the bases for setting performance targets, which in the current case means setting the number of internships and job placements needed to render an inefficient organization such as efficient.

The application of the methodology required the availability and access to the data and information of all the DMUs involved in the study. It was very important to consider the results of the surveys applied to ENCSH students, because it

supports what was reviewed in the literature. The results from DEA and Benchmarking shows that there are many areas of opportunity to improve their service in the unit under study, thus it would be possible to raise its prestige, increase their competitiveness and attractiveness to students, and provide an opportunity to gain and adopt strategies which could satisfy their customers.

5.3.1 LIMITATIONS

All applications of DEA require accessibility to data for the outputs and inputs used in the evaluation. In this research one of the limitations was the availability of certain kinds of what might have been relevant data, due in some cases to confidentiality, and in other cases, data not being measured or captured in the organization's management information system [26]. Initially, a larger set of US schools was contemplated than was actually used in the end. This was due to the fact that some schools did not have the requisite data.

Another limitation, but one relating to the DEA methodology itself, is the issue of what constitutes an output versus an input. In this regard it is sometimes difficult to identify and understand the transformation of inputs to outputs. In order to address this problem, a causal relation was proposed, regarding how the outputs identified were related to what were felt to be the inputs. For the case study, both inputs and outputs were features and characteristics considered by students when selecting a university.

When looking for best practices, there is a difficulty relating to organizations not wishing to share important information regarding to their performance and development. Furthermore, in trying to become part of, or a member of, a group in a social network, such as Linked In, there is a requirement that all members verify that they are current or graduated students from the university in question, thereby allowing access to that group. However, this could be solved through the creation of debates in social networking pages, thus, students and graduated students participate free and could express their ideas and share experiences.

5.4 Contributions

The model of how was developed the research could be applicable to various and different studies for performance measurement and benchmarking, when the objective is increase their market share.

Another contribution of this study is that after the DEA Analysis and the Benchmarking, the ENCSH has a proposed list of best practices which could be adopted and could contribute it for a better performance of their activity.

5.5   Future studies

The following future studies are recommended:

The data and information used herein should be updated and the DEA analysis should be rerun to further validate the benchmark for ITESM.

Gather more data on possible additional factors (inputs and outputs). This would make for a more robust analysis of efficiency of ITESM.

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APPENDIX

7.1 Appendix 1: Copy of the questionnaire

The University and its Customers

SURVEY TO IDENTIFY AS STUDENTS CHOOSE AN INSTITUTION OF HIGHER EDUCATION

* Required

GENDER*   Male ☐ Female ☐

CAREER*

LIN ☐	LAE ☐	LPO ☐	LED ☐
LEM ☐	LLE ☐	LRI ☐	LCC ☐
LCPF ☐	LEC ☐	LCDE ☐	IMI ☐
LAF ☐	LPL ☐	LMI ☐	LDF ☐

SEMESTER*

First ☐	Fourth ☐	Seventh ☐
Second ☐	Fifth ☐	Eigth ☐
Third ☐	Sixth ☐	Ninth ☐

CITY OF ORIGIN *   ☐

COUNTRY OF ORIGIN *   ☐

1. Please qualify your level of agreement according to the following criteria on how to select the Institution where you are studying now. *

Level 1 = Strongly Disagree   5 = Strongly Agree (For each criterion, choose one)

I used several ways of evaluating institutions before making my final decision	1	2	3	4	5
I did some detailed comparisons of institutions before making my Decision	1	2	3	4	5
I researched on the institutions in order to find out what is bad as well as what is good about them	1	2	3	4	5

For me it is important to go on an institution tour before deciding on an institution	1	2	3	4	5
I contacted the institution by web pages or callings in order to get some information	1	2	3	4	5

2. From the following list, which institution did you collect information from? (You can select more than one option)

Instituto Tecnológico y de Estudios Superiores Monterrey (ITESM) ☐

Universidad Autónoma de Nuevo León (UANL) ☐

Universidad de Monterrey (UDEM) ☐

Universidad Metropolitana de Monterrey (UMM) ☐

University in Mexico ☐ Specify _____

University in United States ☐ Specify _____

University in Canada ☐ Specify _____

University in Latin America ☐ Specify _____

University in Europe ☐ Specify _____

University in Asia ☐ Specify _____

University in Africa ☐ Specify _____

University in Oceania ☐ Specify _____

3. From the following list, which institution did you apply for? (You can select more than one option)

Instituto Tecnológico y de Estudios Superiores Monterrey (ITESM) ☐

Universidad Autónoma de Nuevo León (UANL) ☐

Universidad de Monterrey (UDEM) ☐

Universidad Metropolitana de Monterrey (UMM) ☐

University in Mexico ☐ Specify _____

University in United States ☐ Specify _____

University in Canada ☐ Specify _____

University in Latin America	☐ Specify _____
University in Europe	☐ Specify _____
University in Asia	☐ Specify _____
University in Africa	☐ Specify _____
University in Oceania	☐ Specify _____

4. When reviewing information about an institution (s), what was it that you sought? * (You can select more than one option)

General Information Brochure	☐
Information about overseas study programs	☐
Information about sporting programs and facilities	☐
Information about artistic programs and facilities	☐
Admissions policies and procedures	☐
Information about fees and scholarship information	☐
Records of academic achievements	☐
Information about institution academic research record	☐
Information about courses (degrees or diplomas) offered	☐
Information about social programs and facilities	☐
Student welfare programs and facilities	☐
Other	☐

5. In the following list of items, indicate the degree of importance that had for you *
Level of Importance 1 = Not important 5 = Very important (for each criterion, choose one)

Fees and cost associated with attending	1	2	3	4	5
Image or reputation of the institution	1	2	3	4	5
Location of the university	1	2	3	4	5
Degree programs offered	1	2	3	4	5
The difficulty of the academic program of study (it was hard)	1	2	3	4	5
Educational facilities such as the library, classrooms and labs	1	2	3	4	5
Prestige of course of study	1	2	3	4	5
Educational opportunities such as exchange programs, internships, research	1	2	3	4	5

Prestige of institution teaching staff	1	2	3	4	5
Opportunities to meet people and societies	1	2	3	4	5
Job placement programs and the ability to get a good job on graduation	1	2	3	4	5
Availability of part time study options	1	2	3	4	5
Availability of financial aid and scholarship	1	2	3	4	5
Availability of student welfare programs	1	2	3	4	5
Availability of on-line courses	1	2	3	4	5

6. In the following list of items, select 5 that supported your decision to enroll in the institution in which we now study

Fees and cost associated with attending ☐

Image or reputation of the institution ☐

Location of the university ☐

Degree programs offered ☐

The difficulty of the academic program of study (it was hard) ☐

Educational facilities such as the library, classrooms and labs ☐

Prestige of course of study ☐

Educational opportunities such as exchange programs, internships, research ☐

Prestige of institution teaching staff ☐

Opportunities to meet people and societies ☐

Job placement programs and the ability to get a good job on graduation ☐

Availability of part time study options ☐

Availability of financial aid and scholarship ☐

Availability of student welfare programs ☐

Availability of on-line courses ☐

7. Where did you collect other (promotional) information about the universities? * (You can select more than one option)

Newspaper articles (not advertising) ☐

Advertising ☐

Information provided by professionals ☐

The internet ☐

A handbook on institutions such the "Good Universities Guide" ☐

Advertising in magazines or journals ☐

School visits to institutions ☐

Visits to your school by institutional representatives ☐

Careers information collected from school or work ☐

Other (please specify) ☐

8. For your final decision, which of the people on the list had an influence? * (You can select more than one option)

Parents, brothers and/or
sisters ☐

Friends, classmates and neighbors ☐

Careers and counselors, teachers and staff at
school ☐

Teacher and staff of the HEI ☐

Students enrolled at the current institution ☐

Training and development staff for work ☐

Others ☐

9. As a student at ITESM, and if you have financial support (scholarship and/or credit) by the institution, how satisfied are you with what you offer? *

0% - 19% ☐

20% - 39% ☐

40% - 59% ☐

60% - 79% ☐

80% - 89% ☐

90% - 100% ☐

No Aplica ☐

10. Being part of the ITESM, How would you evaluate the ability of teaching your teachers and their willingness to support and advice outside the classroom?

0% - 19%	
20% - 39%	
40% - 59%	
60% - 79%	
80% - 89%	
90% - 100%	

7.2 APPENDIX 2: Solving DEA by applying softwares

7.2.1.1 Efficiency analysis software: Frontier analyst

This software is designed to help managers, researchers and analysts to measure and improve the performance of the organization under study. They tried to achieve better results from the resources available to them. DEA is a powerful technique used by Frontier Analyst[27].

Some guidelines for developing inputs and outputs in this software are:
- Each factor must be designated as either an input or an output
- The inputs and outputs included in the analysis should all have the same level of importance. No one input or output is more important than another
- Numerical values must to be given to all the factors, it must be possible to measure (quantify)
- Inputs can either be designated controlled or uncontrolled. A controlled input is one which the management of the unit has control over and as a result can alter the amount of it used. An uncontrolled input is one over which the management does not have control and cannot alter its level.
- An increase in the value of an input should no result in a decrease in any output value. If this does happen then the inverse of the values of that input should be used in the analysis.
- The data values for any of the inputs and outputs must be positive
- The number of inputs and outputs used should be as small as possible, in order to ensure effective discrimination between the units, subject to them reflecting adequately the function of the units.

This software allows users to take account of all the important factors that affect a unit performance to provide a complete and comprehensive assessment of efficiency. This is done by converting the multiple inputs and outputs into a single measure of productive efficiency. By this way, it is easy to identify those units which are operating relatively efficiently and those which are not. The efficient units, those making best use of resources, are rated as being 100% efficient while the inefficient ones achieve lower scores. This software helps to generates efficiency scores for all the units being analyzed. It shows how much inefficient units need to reduce their inputs or increase their outputs in order to become efficient. It also identifies the units which are performing best and their operating practices can then be examined to establish a guide to "best practice" for others to emulate"[27].

After the analysis acquired by the use of the software, it leads an easy way to get a clear vision of how the organization is developing their efforts in the market.

7.2.1.2 Data envelopment analysis with spreadsheets

DEA has being applied in a variety of efficiency evaluation problems. Sometimes managers want to conduct performance evaluation and analyze decision alternatives without sophisticated modeling programs; by this way spreadsheet modeling in Microsoft Excel is a suitable vehicle. It has been recognized as one of the most effective ways to evaluate decision alternatives. It is easy for the managers to apply various DEA models in spreadsheets by using Microsoft® Excel and Solver. With the assistant of the developed DEA spreadsheets, the user can easily develop new DEA models to deal with specific evaluation scenarios. [22]

The spreadsheet modeling approach is very helpful to managers, researchers, and practitioners. There are two versions which includes a DEAFrontier software for both Excel 97-2003 and Excel 2007-2010. DEAFrontier is a DEA Add-In for Microsoft Excel and offers the user the ability to perform a variety of DEA models and approaches – it provides a custom Excel menu which calculates more than 150 different DEA models. [22]

Before you run the DEAFrontier software, Excel must be open or loaded and the entire Solver parameters dialog box must at least be displayed in the Excel session. Depending of the version of the solver, the use of the specific DEAFrontier Software is required. Such as, using standard Excel Solver at Excel 97, 2000, 2003 and XP, it is necessary to open the "DEAFrontierFree_SolverPlatform.xla". Otherwise, using standard Excel Solver at Excel 2007 or 2010, should be opened "DEAFrontierFree.xlam". [22]

The following Steps show how DEAFrontier Software works under Excel 97, 2000, 2003, or 2007:

1. Step 1: open the Excel
2. Step 2: load the Excel Solver
3. Step 3: load the DEAFrontier software

Under Excel 97, 2003 & XP, you will see a new Menu item "DEA" at the end of Excel Menu. Now, the software is ready to run. (Please see the Format for Data Sheet for proper setup of data sets.) [22]

For Excel 2007 & 2010: to locate the DEA Menu, select the Add-Ins tab and navigate to the DEA menu option. [22]
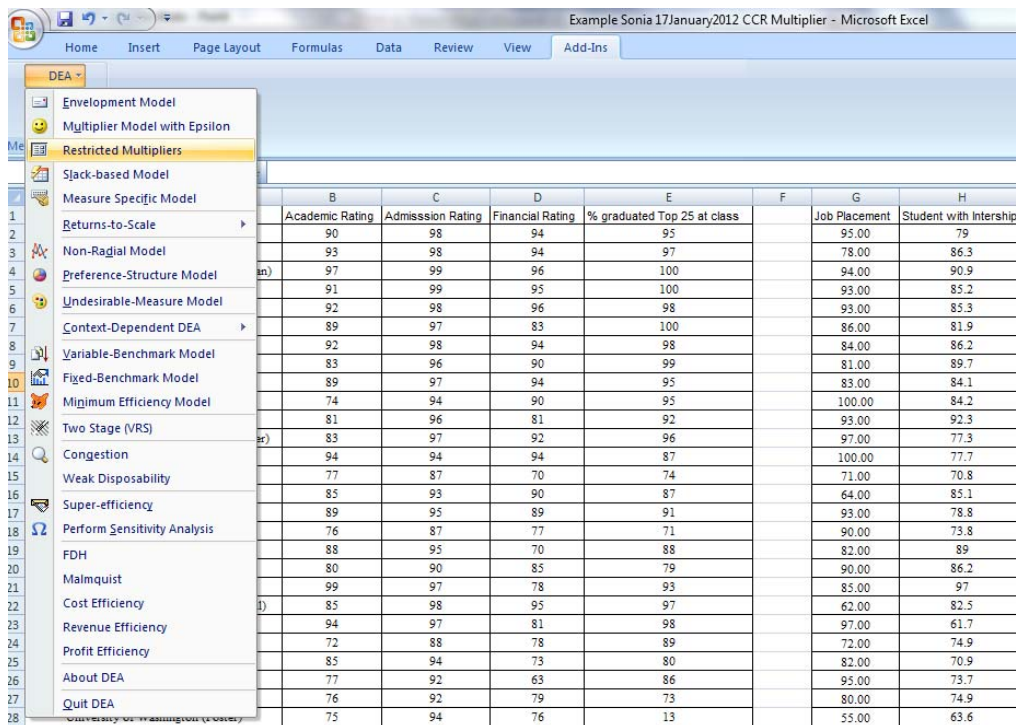
Example Sonia 17January2012 CCR Multiplier - Microsoft Excel

Home   Insert   Page Layout   Formulas   Data   Review   View   Add-Ins

DEA ▾

- Envelopment Model
- Multiplier Model with Epsilon
- Restricted Multipliers
- Slack-based Model
- Measure Specific Model
- Returns-to-Scale ▸
- Non-Radial Model
- Preference-Structure Model
- Undesirable-Measure Model
- Context-Dependent DEA ▸
- Variable-Benchmark Model
- Fixed-Benchmark Model
- Minimum Efficiency Model
- Two Stage (VRS)
- Congestion
- Weak Disposability
- Super-efficiency
- Perform Sensitivity Analysis
- FDH
- Malmquist
- Cost Efficiency
- Revenue Efficiency
- Profit Efficiency
- About DEA
- Quit DEA

	B	C	D	E	F	G	H
1	Academic Rating	Admisssion Rating	Financial Rating	% graduated Top 25 at class		Job Placement	Student with Intership
2	90	98	94	95		95.00	79
3	93	98	94	97		78.00	86.3
4	97	99	96	100		94.00	90.9
5	91	99	95	100		93.00	85.2
6	92	98	96	98		93.00	85.3
7	89	97	83	100		86.00	81.9
8	92	98	94	98		84.00	86.2
9	83	96	90	99		81.00	89.7
10	89	97	94	95		83.00	84.1
11	74	94	90	95		100.00	84.2
12	81	96	81	92		93.00	92.3
13	83	97	92	96		97.00	77.3
14	94	94	94	87		100.00	77.7
15	77	87	70	74		71.00	70.8
16	85	93	90	87		64.00	85.1
17	89	95	89	91		93.00	78.8
18	76	87	77	71		90.00	73.8
19	88	95	70	88		82.00	89
20	80	90	85	79		90.00	86.2
21	99	97	78	93		85.00	97
22	85	98	95	97		62.00	82.5
23	94	97	81	98		97.00	61.7
24	72	88	78	89		72.00	74.9
25	85	94	73	80		82.00	70.9
26	77	92	63	86		95.00	73.7
27	76	92	79	73		80.00	74.9
28	75	94	76	13		55.00	63.6

Figure 1: DEA Menu Option in Microsoft Excel 2007

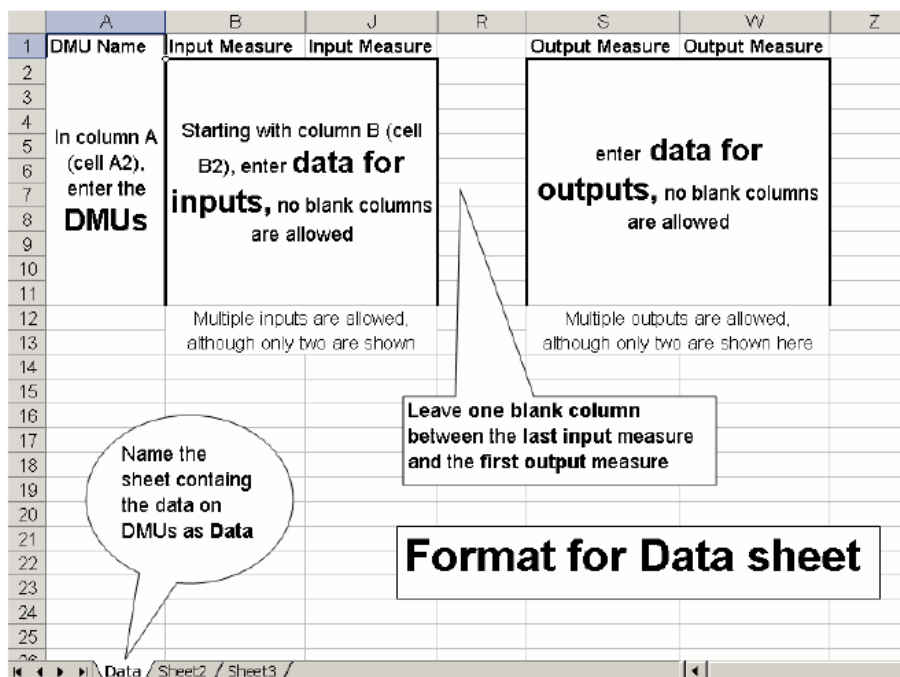It is required that in the Excel sheet, the user places the data as shows in the following figure

	A	B	J	R	S	W	Z
1	DMU Name	Input Measure	Input Measure		Output Measure	Output Measure	

In column A (cell A2), enter the DMUs

Starting with column B (cell B2), enter **data for inputs,** no blank columns are allowed

enter **data for outputs,** no blank columns are allowed

Multiple inputs are allowed, although only two are shown

Multiple outputs are allowed, although only two are shown here

Leave one blank column between the **last input** measure and the **first output** measure

Name the sheet containg the data on DMUs as **Data**

Format for Data sheet

Data / Sheet2 / Sheet3 /

Figure 2: Data Sheet Format [22]

7.2.1.3 Restricted multiplier models in spreadsheets

To run the multiplier models, select the "Multiplier Model with Epsilon" menu item. As shown in the following figure, the default ε value = 0. The user can specify its own non-zero. The results are reported in a sheet named "Efficiency Report".
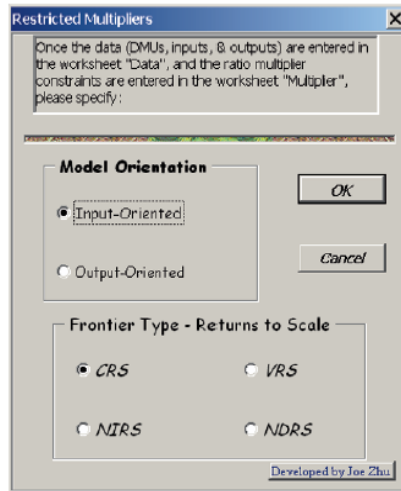

Figure 3: Menu option at Restricted Multiplier Model [22]

We need to first set up a sheet that contains the multiplier restrictions (or Assurance Regions (ARs)). Then the data in the "AR" sheet should be entered as shown in the following Figure [22]

Figure 4: Restricted Multipliers in Excel Spreadsheet[22]

To avoid any errors, it is suggested to copy and paste the input and output names from the "data" sheet when entering the information into the "Multiplier" sheet. If the input (output) names in the two sheets do not match, the program will stop. [22] The results are reported in sheet "Efficiency Report". [26]

Note that you can also add ARs that link the input and output multipliers for the "Restricted Multipliers". Note also that if the ARs are not properly specified, then the related DEA model may be infeasible. If that happens, the program will return a value "-9999" for the efficiency score. [26]